JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

Vol. 24 JULY, 1932 No. 7

PROGRESS TOWARD FILTRATION IN CHICAGO[1]

By Myron B. Reynolds[2] and Arthur E. Gorman[3]

Although not generally realized, Chicago was one of the first American cities seriously to consider filtration of its water supply. In the early period of the Civil War, Chicago was faced with an acute water supply problem. The water taken in through its shore intake at the lake front opposite Chicago Avenue was grossly polluted by domestic sewage and wastes from such offensive plants as packing houses, tanneries, glue works, breweries, etc., located on the Chicago river and along the lake front. Several methods of solving this problem were proposed, but only three were given enough consideration to be reported on in the Annual Reports of the Board of Public Works. One was the construction under the lake of a tunnel to an intake beyond the zone of shore pollution, about 2 miles off shore at Chicago Avenue. A second was a similar tunnel 5 miles to the north of this tunnel with a brick aqueduct on land leading to the pumping station. The third was a natural filtering or settling project. Work on the tunnel began in March, 1864 and was completed in 1867. Inci-

[1] Presented before the Illinois Section meeting, April, 13, 1932.

[2] City Engineer, Bureau of Engineering, Department of Public Works, Chicago, Ill.

[3] Engineer of Filtration, Bureau of Engineering, Department of Public Works, Chicago, Ill.

dentally this 5-foot tunnel is still in operation serving the Chicago Avenue station today.

The filtration plan was a unique one. The system proposed is hardly descriptive of what we consider water filtration today. It would have been an infiltration gallery. The plan was to dig a deep trench 10 feet below lake level close to and paralleling the lake shore just north of Irving Park Boulevard. This trench was to be about 3000 feet long and by means of lateral infiltration of the water from the lake purification was to be accomplished. It was proposed that the water so filtered be delivered to the pumping station at Chicago Avenue either by means of an open trench about 5 miles long or by pumping through a brick aqueduct. The idea of this infiltration trench was obtained from a similar practice at Hamilton West Canada. But the engineers in the city's service at the time were skeptical of this plan because of the probability of the filters becoming clogged with a reduction in capacity as used. However, the filtering project must have had influential supporters, for in order to expedite the adoption of either this or one of the tunnel plans the city charter was amended by an act of the Illinois Legislature on February 13, 1863, in which power was given to the city:

"to construct such aqueducts along the shore of Lake Michigan, or in the highways, elsewhere in Cook County, and to construct such pumping works, breakwaters, subsiding basins, filter beds and reservoirs and to lay such water mains, and to make all other constructions in said county, as shall be necessary in obtaining from Lake Michigan a sufficient and abundant supply of pure water for said city:"

"to extend aqueducts, or inlet pipes, into Lake Michigan, so far as may be deemed necessary to insure a supply of pure water, and to erect a pier or piers in the navigable waters of said lake, for the making, preserving and working of said pipes or aqueducts."

To assure the city complete authority to proceed with one of these projects the sanction of Congress was requested for these two sections of the amended city charter. Before final action was taken at Washington, however, a decision was made in favor of the tunnel project. Therefore Congress sanctioned only that section relating to the construction of the tunnel, adding as a proviso "that such piers shall be furnished with a beacon light, which shall be lighted at all such seasons and hours as the light on the pier at the entrance of the Chicago River."

The adoption of the lake tunnel plan definitely eclipsed the filtra-

tion scheme at the time and it may be truly said that the success of Chicago's water tunnels in delivering a reasonably satisfactory water to the city has done much to postpone action toward filtration even to the present day. Other influencing factors which have retarded action on filtration have been: the improvement of the quality of the lake water brought about through the construction of the intercepting sewers, the diversion of the polluted waters of the Chicago and Calumet rivers through the drainage canal and the excessive consumption of water in Chicago through lack of metering.

Filtration has been more or less advocated since those early days, but the first definite step towards filtration was not made until 1925. Then City Engineer John Ericson submitted a report to the Commissioner of Public Works A. A. Sprague, recommending the construction of an experimental filtration plant in order that Chicago might obtain the necessary information on which to base design features and construction costs for full sized structures. As a result of this report the City Council in 1926 appropriated $50,000 for research on filtration. City Engineer Ericson placed the responsibility for carrying out this research on Arthur E. Gorman, then Chief Sanitary Engineer in charge of this newly organized Division of Water Safety Control in the Bureau of Engineering.

In September, 1926, Mr. John R. Baylis, Chemist in charge of the Montebello Filtration Plant of the City of Baltimore, was employed to conduct the research work. A modest, well equipped chemical laboratory was built at the 68th Street pumping station and there Mr. Baylis conducted his preliminary research on the chemical treatment and filtration of Lake Michigan water. As a result of his preliminary studies the present experimental filtration plant was designed largely along Mr. Baylis' ideas and under the immediate direction of Alfred H. Marshall, designing filtration engineer.

This experimental filtration plant has been described fully in the technical literature. Water works men from all over the world have visited this plant and here Mr. Baylis and his assistants have conducted experiments, reports on which have been very valuable contributions to present day knowledge of the art of water purification. In designing this plant two features not related at all to the technical phases of the work were incorporated, the value of which have been well demonstrated. One was the beautification of the exterior of the plant to harmonize with the high class residential district in which it is located. The other provision was for dispensing the filtered

water to the public as an educational proposition. Because of the exterior beauty of the plant and its surroundings there has never been any objection on the part of property owners to the location of this plant. In fact, it is pointed out with pride by citizens residing in the neighborhood. The popularity of the filtered water is evidenced by the large number of persons calling at the plant to obtain water for personal or family use. They average from four to five thousand a week to as high as ten thousand per week during periods when the lake water is objectionable.

The experimental plant was put into operation April 23, 1928 and has been operating continuously ever since. It is unfortunate that the research program originally planned to cover a two-year period of extensive research was handicapped by lack of appropriation for adequate technical personnel after the plant had been built. But in spite of this difficulty the experiments which have been performed are of inestimable value to the city, and will permit an economical design of filtration plants which would not have been possible without these experimental studies. The major portion of the research work has been completed and during the last six months three very valuable reports have been submitted to City Engineer M. B. Reynolds on the research findings.

EXPERIMENTS CONDUCTED

Sixty-three major experiments have been conducted up to April 1, 1932, on methods of treating Lake Michigan Water for purification.

The removal of taste and odor has been one of the major problems. Instead of waiting for the taste periods to occur in the lake water, the water at the plant has been polluted on numerous occasions with known quantities of taste and odor producing compounds, especially phenolic wastes from by products coke plants and oil refinery wastes from industries located in the Calumet region of Illinois and Indiana. In this way the plant is not dependent upon natural taste periods, except for the taste produced by algae or other microscopical organisms. A brief summary of the experimental findings contained in Mr. Baylis' reports are herewith presented.

CHEMICAL TREATMENT

Aluminum sulfate

In so far as producing a coagulation sufficient to cause the water to be filtered clear is concerned, aluminum sulfate has been found

very efficient for treating Lake Michigan water. The fact that the Chicago water is so clear at times and the aluminum sulphate does not add material to the water which produces a rapidly settling coagulation, makes it necessary at times to use some other treatment to produce filter runs which are long enough for the practical operation of a large plant.

Lime and ferrous sulfate

The rapidly settling precipitate produced by this treatment overcomes the short filter runs produced by high microscopical growth in the lake water and gives filter runs long enough for practical operation of a large plant. This treatment, however, is slightly more expensive than the treatment with aluminum sulfate, even when the value of the softening is taken into consideration. At the present market price of ferrous sulfate and chlorine, the cost of coagulating Lake Michigan water in this manner is about the same as for an aluminum sulphate. The cost of the two treatments will vary, however, depending upon the market price of the materials.

Lime and chlorinated ferrous sulfate

The use of lime to produce an artificial turbidity will be necessary at Chicago during periods when the microörganisms are in abundance. The experiments indicate that the use of chlorinated ferrous sulfate will be better than the use of ferrous sulfate alone, and it is likely that the large plants will be operated in this manner for at least several months each year. The quality of the water produced by the use of chlorinated ferrous sulfate appears to be equal to that produced by aluminum sulfate.

Other treatments

Other treatments such as the excess lime treatment, lime and sodium aluminate, sodium aluminate and aluminum sulfate, have been tried on a plant scale, and while it has been found possible to produce an excellent quality of water with each, they do not appear to be economical for the Chicago water. Several other materials have been tried in the laboratory, and with the exception of ferric chloride and fer-alum, none of them appears to be practical. Fer-alum has been tried on a plant scale as well as in the laboratory and it offers some possibility of being suitable for coagulating the Chicago water if it is a product that may be sold considerably cheaper than aluminum sulfate.

MIXING BASINS

Time of mixing

The amount of suspended matter in the Chicago water is fairly low compared with the amount found in many waters, consequently it is necessary to add only a very small amount of coagulant, if the only consideration is to coagulate the water to the extent that it will filter clear. Using the minimum quantity of coagulant necessary for clarification, the experiments indicate that a mixing period of at least one hour is required to produce fairly large size particles of flocculated matter at Chicago during the winter months. The low cost of mixing compared with chemical costs shows that it is not economy to sacrifice mixing time by the addition of an excess of coagulant, unless the period requiring the long mixing time is of very short duration. The most economical mixing time when everything has been taken into consideration has not been determined accurately, but is believed to be about 45 to 50 minutes. Experiments have indicated that mechanical mixing basins are to be preferred in treating Lake Michigan water at Chicago due to flexibility afforded for use of various coagulants.

A study is being made of existing practice in the design of mixing basins throughout the United States, and of the design of the basins for large plants in Chicago will be as a result of our own investigations and what is accomplished in other plants. We are also investigating the desired mixing time and the violence of agitation, and will study the designs of large installations in other plants to see how this may be most economically accomplished.

SETTLING BASINS

Time of settling

A large number of measurements have been made at the Experimental Plant on the amount of coagulated matter settled within certain periods. From these studies we hope to determine the rate of settling which may be expected for a given treatment. Usually there is no trouble in obtaining fairly rapid settling of the flocculated particles when the turbidity of the water before the treatment is over 25 p.p.m. The average turbidity of the Chicago water, however, is about 10 p.p.m. and there may be long periods of time in which the turbidity is continuously below 10 p.p.m. The microörganisms which may be responsible for a large portion of this turbidity have

a specific gravity almost exactly that of water. For this reason the entrapment of the microörganisms by the coagulant does not add weight to the flocculated particles to increase their settling rate, which is desired.

The experiments indicate it will be necessary to add something to the water to produce an artificial turbidity to obtain a more rapid settling flocculation. The addition of enough lime to produce partial softening of the water appears to be a cheap means of producing an artificial turbidity. With the various factors which influence the rate of settling it has been very difficult to determine the most economical time. The experiments show a settling time of at least four hours to be very desirable. When everything is taken into consideration it may be found that the settling period should be longer.

Type of basins

The type of settling basins will depend somewhat upon the type of treatment adopted. If the water is partially softened, as the experiments indicate to be advisable, this treatment will be desirable for perhaps 50 percent of the time. The first part of the settling should be provided for continuous sludge removal, followed by a longer period of settling in plain sedimentation tanks. The experimental work indicates that settling basins should be so constructed that continuous sludge removal devices may be installed if the water is partially softened. If it is decided to start operation with the use of a coagulant only, the continuous sludge removing devices may not be installed. While there has been no great demand at the present time for softening water with a hardness of that of Lake Michigan water the trend in water treatment is towards softer water. It is considered likely that within the next 15 to 20 years there may be a real demand for softening the Chicago water. This will be taken into consideration in the design of settling basins that they may be suitable for handling softened water without having to be reconstructed.

FILTERS

Design of filters used in experimental plant

Filters of standard design probably of 4 m.g.d. units each will prove most economical for our full size plant.

Washing

Experiments have been conducted on washing filters at various rates and by two different methods, first, with all water delivered under the beds in the usual manner and secondly, a combination of underneath wash and surface wash.

An experiment was run for a period of about 18 months in which one filter was washed at a rate of 20, another at 24- and another at 38-inch vertical rise. These filters were washed in the usual manner by applying all of the wash water underneath the beds. The time of washing was 4 minutes for the lower rate, 3 minutes for the 24-inch rate and 2 minutes for the 38-inch rate. In addition to this, one filter was washed by applying water to give a vertical rise of about 20 inches underneath the bed and 4 inches was applied through the surface wash. This gave a total rise of 24 inches. Another filter was washed in the same manner, but the rate was only about 20 inches for the total water used. No difference in the quality of the water produced by washing the filters at different rates and by different methods was detected. The filter washed at the rate of 20-inch vertical rise accumulated quite a good deal of mud at the surface of the bed, yet the results were very good and this filter usually gave longer runs than the other filters. The filter washed at 24-inch vertical rise per minute kept in fairly good condition, but formed surface cracks and at times there was a considerable number of mud balls at the surface. The filter washed at 38-inch vertical rise kept in better condition than the other two filters washed at a lower rate, but the condition of the bed was not perfect. Both of the filters in which the surface wash was used were maintained in very much better condition than the other filters. It is, therefore, probable that provision for surface wash will be incorporated in the Chicago design.

Sand size

Extensive experiments on the effect of varying the size of sand are under way, but the experiments have not been run long enough to form definite conclusions.

Sand depth

Experiments are also being made on the effects of the depth of the sand in the filter bed. These experiments have not been run long enough for conclusions to be formed.

Filtration rates

A large number of experiments have been run in which the rate of filtration has been varied over a very wide range. During most conditions of the lake water it would be possible to use a rate of filtration considerably in excess of two gallons per square foot per minute. If it were not for the periods of weak flocculation, which may occur during the winter months, it would be safer to count on the filters producing satisfactory results when operated at a rate of 3 gallons per square foot per minute. Due to the difficulty in preventing the passage of flocculated matter during the periods of weak flocculation, it probably will be best to design the plant on the basis of a maximum rate during the peak load of the day not to exceed 2½ gallons per square foot per minute. This is 125 percent of standard rates for rapid sand filters. Operating results at present show that the maximum demand is 134 percent of average which would be equivalent to 2.7 gallons filtering rate.

The fact that the periods of weak flocculation occur only in the winter months, when the peak load demands are not as high as they are in the summer months, the 3 gallon per square foot per minute rate—which is suitable for summer conditions—may be the rate which will set the size of the filter area for the first plant. An economic balance between filtration rates, consumption load and plant costs must be made before a decision on the rated capacity of the filter units to be used for design can be made.

EXPERIMENTS ON TASTE AND ODOR REMOVAL

Almost as much time has been given to experiments on taste and odor removal as on the other work. One of the reasons for this is that so little was known about taste and odor elimination prior to starting the experimental work. Taste and odors in the Lake Michigan waters are also a serious problem at Chicago. When this work was first started it was evident that methods of testing for taste producing compounds were very unsatisfactory. After about 7 or 8 months of intensive research work, an accurate quantitative method for phenol determinations was developed, and is known as the Baylis Modification of the Gibbs Method.

The work has not been confined to the elimination of phenol from water and considerable work has been done on other taste producing compounds, such as the waste products from oil refineries and the taste produced by microscopical organisms. Several methods of

removing objectionable tastes have been developed, and as a result it is now possible to remove practically any taste producing compound likely to be found in water used for a public supply.

Activated carbon

A very thorough study has been made of the use of activated carbon in taste and odor removal. As a result of pioneer work at this plant nearly 200 water purification plants in the United States now use activated carbon during periods when the water has a taste. It was found in the early part of the work on activated carbon and charcoal that materials on the market varied greatly in their adsorptive capacity. It was necessary to develop a method by which the efficiency of a carbon could be determined. It has been found that the phenol adsorptive capacity of the carbon gives the best indication of its suitability for the removal of taste producing compounds from water. Had the accurate quantitative tests for phenols not been developed by Baylis[4] it would have been almost impossible to have developed a suitable test for determining the efficiency of the carbonized materials.

The work on activated carbon, both in beds in granular form and in basins as a powder, has been very encouraging. A large portion of our experiments have been on beds of granular activated carbon. We are not prepared at the present time to state which method will be recommended, but carbon appears to be the only hope of removing some of the taste producing compounds which may be expected in the Lake water off Chicago. Its use will be recommended in one or the other form.

Ammonia-chlorine treatment

A large number of tests have been made on the use of ammonia with chlorine to prevent chlorinous tastes or tastes made more pronounced by the addition of chlorine to water. A summary of this work has been published in an outstanding article by Sanitary Engineer H. H. Gerstein.[5] It is very likely that ammonia will be used as a part of the treatment of the Chicago water after the filtration plants have been construction.

[4] *Authors' note.* In recognition of this work on taste and odor removal Mr. Baylis was given the John M. Goodell award by American Water Works Association at the annual convention, Memphis, Tennessee, May 4, 1932.

[5] This Journal, vol. 23, no. 9, September, 1931.

Other methods of taste elimination

Other methods of taste elimination have been investigated. The super-chlorination treatment followed by dechlorination would be effective in removing a large percentage of the tastes in the Chicago water, but would not remove all of them. If beds of granular activated carbon are constructed in connection with the filtration plant, experiments indicate that it would be better to super-chlorinate the water and depend upon the carbon for dechlorination. Active carbon has been found to be a very effective dechlorinating substance. A bed of material after being in use three years before being removed for reactivation was almost as effective in dechlorinating the water as the new material. The material had reached its adsorptive capacity for taste producing compounds not eliminated by the super-chlorination and it was desirable to reactivate for the purpose and not for dechlorination.

The use of potassium permanganate for taste elimination has been investigated on a laboratory scale, but has not been tried in the plant. It is effective for the removal of certain tastes, but like the super-chlorination treatment, does not eliminate all objectionable tastes which occur in the Chicago water.

FILTRATION PLANT LOCATION AND DESIGN

During the period 1928 to 1931 progress was made in preliminary design of filtration plants and in studies of suitable locations for these structures. These studies were based on the construction of four plants to be located along the lake front in the vicinity of the four major lake tunnel systems. Capacities were based entirely on the present day policy of not metering small domestic consumers, estimating a per capita consumption of about 300 gallons per day. They provided for the use of the present intakes and tunnels as a source of supply, with an emergency intake from the lake. Each structure would project into the lake about one half mile, using cofferdam construction, with a low lift pumping station on the east or lake end. The water from the pumping station would then flow through the plant in the following order: mechanical mixing basins, primary and secondary settling basins, filters and reservoirs, the last named being on the westerly or land end of the structure. This work was carefully done under the direction of Alfred H. Marshall, of the staff of Orville B. Carlisle, Engineer of Water Works Design, and the completion of these preliminary plans marked a very important step in the advancement of filtration for Chicago.

A second important forward move toward filtration was the placing on the general ballot at the November 4, 1930 election of a proposition "Shall the City Council pass an ordinance for filtration of Chicago's Water Supply?" This was brought about through the efforts of Richard W. Wolfe, then Commissioner of Public Works, and employes of the Public Works Department. A well organized and effective publicity program was carried out by the Bureau of Engineering, L. D. Gayton acting City Engineer, in the months just preceding this election. The proposal was carried by a substantial majority consisting of 68.3 percent of all votes cast and over 50 percent in every ward in the city. Only one other proposition on the ballot, except three companion propositions for the state at large on the prohibition question, drew a larger percentage of favorable votes, that being the annexation of the Village of Beverly. This expression of public sentiment in favor of clean pure water was most impressive, and is most encouraging to all who are interested in filtration in Chicago.

Shore intakes

During the last year there have been several developments which have indicated the wisdom of making changes in the first plan of having four plants and building them as long, pier-like structures with flow entirely in one direction. Particular attention has been given to design and location features for a filtration plant to serve the south side. The results of findings at the experimental plant have indicated there is no material advantage in obtaining water from the present intakes insofar as treatment for filtration is concerned. The results show that the higher turbidity in water which could be obtained from intakes near shore to be advantageous in assisting coagulation and that the degree of contamination of the lake water at such shore points would not be a serious factor in the treatment processes, or costs. For this reason designs have been started based upon the use of intakes drawing water directly from the lake off the east end of filtration plants. The head saved by avoiding friction losses in flow through the tunnels would be at least 8 feet, a substantial operating saving.

Furthermore, the use of the shore intakes at the filtration plants would give the city very substantial increases in capacity for the distribution of filtered water to pumping stations. This would be accomplished by having the lake shore pumping station nearest a filter plant supplied directly from the filtered water storage reservoir

through a special short tunnel. Operation from this reservoir to the nearby pumping station and to the service tunnel to other stations could be developed on a shunt system similar to the one in use in Detroit, allowing the head on the land tunnel to be maintained constantly at the most economic elevation. The possibilities for economies in the use of shore intakes at the filtration plants may be illustrated in the case of the south side. This system now has an economic capacity of about 420 m.g.d. and supplies all of the Roseland and Western Avenue pumping stations and part of the 68th Street pumping station. The last named station receives about 80 m.g.d. from the 68th Crib intake and tunnel. When the filtration plant is built and the elevation of the filtered water reservoir is at +6 Chicago datum the southwest land tunnel alone will have a capacity of about 457 m.g.d. If the 68th Street Station were served wholly from the filtered water reservoir by a short tunnel it could easily be increased to have a capacity of 200 m.g.d. or more. The combined capacity for the south side filtered water would then be 657 m.g.d. whereas today it is about 500 m.g.d., or 420 from the southwest lake and land tunnel and 80 m.g.d. from the 68th Street tunnel.

This present system is already reaching its capacity for maximum flows and it is estimated that with a continued consumption of about 300 gallons per capita per day additional tunnel capacity should be provided for the south district in about 1938. With a water conservation program in effect and a liberal per capita consumption of say 170 gallons per day the service capacity for filtered water to pumping stations under the suggested plan would be ample for a population of 3,900,000 people on the south side only.

It appears that the best location for the first filtration plant would be along the lake front in the vicinity of the southwest and 68th street lake tunnels. This would make connection costs to the present tunnel for filtered water distribution a minimum and provide for a short service tunnel to the 68th Street pumping station from the filtered water reservoir.

The location of the filtration plant along the lake front requires negotiations with the South Park Commissioners and private land owners having riparian rights. Steps in this direction have already been made and the indications are that we shall receive the full coöperation of all concerned in the great project.

The first construction work to be done would of course be the coffer-

dam. Careful studies of the economic size and section of this structure are now under way. A definite recommendation in this regard must await further studies.

An attractive layout for expansion from three to five units is proposed. An original three unit plant is to be built within the cofferdam equally distant from the side walls. The space between the structures and the cofferdam walls would be filled hydraulically with material from the bed of the lake and grassed as a parkway. The fourth unit would then be constructed, when needed, by simply removing the fill on one side of the cofferdam. The filter capacity would be obtained by extensions of the filter building, either at the north and south ends or the land side. Similarly a fifth unit could be installed, when all available space within the cofferdam would be occupied.

Because of the consideration which is being given to the practicability of a waterway along the Chicago lake front between the mouth of the Chicago river and Calumet Harbor, protected by an outer breakwater, special studies have been made in regard to the layout of the filtration plant and the relative economy of limiting the distance the structures project into the lake. Obviously with a waterway near shore for smaller craft, such as barges, a filtration plant projecting into the lake a half mile might be a serious obstruction.

Recent studies have indicated that an efficient design could be made, reducing the length of the plant so that it projects into the lake not over 1500 feet. This would be more economical in the construction of the cofferdam, but has possibilities of intake troubles because of shallower water. The earlier plans were to have the filter plant extend into the lake 2600 feet. This would place the inlet in 20 to 22 feet of water. With the shortened structure the inlet would be in about 18 feet of water, dependent on location. In the latter designs the same layout as in the earlier ones has been used, but instead of having the filters extending in an east and west direction they would run at right angles to the settling basins making a wider structure along shore, the arrangement of units resembling the letter "T" in shape.

Should the plan for a shore waterway be adopted the main water intake for the filtration plant would of course be located on the lake side of the breakwater protecting the waterway, with a tunnel under the channel to the plant and probably a secondary intake at the east end of the plant. These studies are in a preliminary stage, but

are a part of the progress which is being made toward an economic and practical design.

South side plant

It is evident that the first filtration plant should be built to serve the south side. Our records show that the quality of the water taken in through the 68th and Dunne intakes has been increasingly inferior during the last five years. The indications are that, while the Sanitary District's improvements scheduled for the Calumet region will reduce to a marked degree pollution of the lake from the Calumet river, it may be several years before other sources of pollution in Indiana—both domestic sewage and industrial wastes—will be eliminated from the southern end of the lake. Much progress has been made in eliminating industrial wastes on a coöperative program with the industries concerned. We are still having difficulty with certain trade wastes, especially from oil industries. It is practically impossible to eliminate them under our present method of obtaining water.

It appears that a rational program for developing filtration in Chicago will be to build one filtration plant at a time, starting with the south side. This is logical from the standpoint of meeting the worst condition first, as well as working out the financing of filtration plants and in designing for future structures, based on experience in operating the first.

Special studies are being made of revenue and consumption factors with the purpose in mind of developing a practical program for early conservation of water in this section in order that the filtration project may be expedited. It is quite evident that an effective water conservation program must precede filtration. It is believed, however, that when the facts are made known to the citizens of this section they will gladly exchange the privilege of water wastage for filtration. When filtered water is supplied to the south side it is planned to close valves in the distribution system so that the area served with filtered water can be definitely defined and the rates increased in this district to such an amount as is authorized to absorb the cost of producing purification. It is our belief that the deferred expenditures in new plant structures which the south side would need, should the present high rate of consumption continue, would more than offset the cost of the filtration plant and that payment from the general water fund for construction of this filter plant would

be an equitable plan. In recent years the major expenditures from the general water fund have been for central and north district improvements, and unless a water conservation program is adopted it is the south side which will need the next new tunnel.

The twin programs—water conservation and filtration for Chicago—are dependent on their acceptance by the people. This will require a well developed educational campaign based on reliable engineering data. To this end a great deal of research work is being conducted and we confidently believe that our program will be well received by our citizens.

DISCUSSION

ALFRED H. MARSHALL:[6] I think the authors have presented a very complete record of the activities and progress made to date regarding filtration of Chicago's water supply.

It has been suggested that you may be interested in hearing of some of the difficulties we have had with our preliminary planning during the past few years. It has ever been a question as to whether or not a filtration project could be successfully carried out unless provision was made for the entire city as a unit to participate in its cost and benefits. The financial requirement and stupendous work involved with such an arrangement made a problem.

The plan evolved by the authors to start with an initial development for one section of the city, namely the South District (the city is divided into three water distribution districts, the North, Central and South), and by gradual steps eventually complete the project for the entire city, appears to be one logical way of making a constructive start. With this plan the number of proposed filtration plants would be reduced to three (a former plan proposed four) with entire work concentrated on the development of a complete closed filtration system for the South Side.

Studies are being made of a plan to finance the cost of this project from its own revenue from water sales, plus its proportionate share from the general construction fund.

The past work had to be carried on under an indefinite plan, due to an unsettled metering policy, and the financing of this project remaining an unsolved problem. Nevertheless we kept up constructive activity and many studies and plans were made which were

[6] Engineer of Filtration Design, Bureau of Water, Chicago, Ill.

essential to the carrying on of the work to date. Perhaps the delay helped in some ways, as our preliminary plans, both for arrangement and locations for plants, were undergoing continual revamping, necessitated by the many changes that were made in the Lake Shore line, due to the beautification development being carried on there.

The plans for plant arrangement have changed from time to time. One was much like a long projecting pier. This was the result of a study to develop a typical design that would be adaptable to any one of the locations. In the late studies, however, it has been found that this plan is not adaptable to certain new sites for plants now being considered. This is especially true as to sites relative to a proposed waterway along South Shore, where such projection would not be permissible. It will be necessary to redesign and the new arrangement will somewhat resemble the shape of a tee.

This proposed new plan in arrangement will be about 1500 feet long, about 1000 feet shorter in length than the original plan. This was referred to in the author's paper, wherein they stated "This change in arrangement for plants will require radical changes to be made in our preliminary plans."

As has been stated by the authors, it is the intention to arrange the plants as piers projecting into the lake and to be located as near the existing crib intake tunnels as will be found practicable, the intention being to provide for connection to the tunnels if found desirable. Because of these requirements, we have encountered obstacles at almost every location. At the Wilson Avenue intake tunnel system site, to serve the North District, the shore development when completed will be about 1 mile farther out. Previous to this change we had made plans for a filtration plant at the former shore line, which included a reservoir to serve the Lake View Pumping Station. It was also planned to connect the plant to the intake tunnel system. The intake tunnel connections estimated at the time would cost about one million dollars. Because of the shore change, these connections would cost now about double the original cost, and the plant itself would also cost much more than originally estimated, because of greater depth of water at any available location.

At the Chicago Avenue Intake Tunnel System site, which serves the Central District, the space along the shore line available for a filtration plant is about 2500 feet. A plant providing for future development here would be about 1500 feet in width. Because of the limited space available at this site and the large capacity required,

it was planned to divide the filtration project into two plants, one with a location off Chicago Avenue and the other at about 14th Street along the shore. This plan was abandoned because of the World's Fair project, which later centered its principal activity at this 14th Street location. In the meantime plans for a harbor including a pier adjacent to the Chicago Avenue site, were proposed which if carried out will seriously affect our plans for future development at this location.

On the South Side preliminary plans for the beautification development of the South Shore are in the making. Originally it was proposed to construct a series of islands along the shore forming a lagoon. This plan has been temporarily abandoned. However, this has affected the planning of filtration plants along this shore.

At the 68th Street and Dunne Cribs intake tunnel system site, which serves the South District, the original plan was, as at all crib intake tunnel systems, to connect the filtration plant with these tunnels for raw water supply. The more recent plan as now proposed is to have a direct lake intake and locate the filtration plant as near the intake tunnel system as is found practicable. Connections may be made at any future time if found desirable. The authors have stated in their paper that, because of the favorable results obtained in a lake front survey, coupled with Mr. Baylis's findings, direct lake intakes may safely be used with filtration and crib intakes may eventually be abandoned.

In our quest for suitable filtration plant sites along the South Shore, we invariably encountered obstacles of some kind, generally in the form of islands, lagoons or yacht harbors proposed or under construction. The most recent project now being considered is a waterway proposed to be constructed along the Lake Shore from the Calumet River to the Chicago River. This would include the construction of a breakwater about two thousand feet off and along the shore for this entire distance. It has been suggested that our problem of locating sites would be solved if we plan our work to the outside of this waterway breakwater.

Several possible sites have been studied relative to this proposed waterway; one would be within the waterway and would project off the shore at Jackson Park. Here we would be confronted with shallow water which would not provide sufficient depth for direct intake. Special intake construction would be required and this would add considerably to cost. Other sites within the waterway

permitting greater projection into deeper water would require much greater cost of plant, and these locations would also involve greater cost of discharge tunnel connections because of these locations. Sites on the outside of breakwater would provide ideal conditions for direct intakes, but these would have to be of construction almost equal to existing cribs, which would add greatly to cost. We would also expect to have difficulty with ice, as is now experienced at the existing cribs.

The construction of a plant on the outside of breakwater would have to be of special construction to provide against destructive action of waves, ice and storms. This all would add greatly to cost.

The entire Lake Shore is under continuous change and development. This has had much to do with our plans of arrangement and locations for plants and has necessitated many changes to be made in our plans and estimates of cost.

I wish to emphasize the importance of the plan proposed by the authors in their paper, in which they propose to concentrate on a program to develop a filtration project, in part, as a beginning for one district (there are three water districts), and later follow in gradual steps and effect its completion for the entire city. This plan is now regarded as a logical solution to our problem of "How to get started toward actual construction."

CORROSION IN NEUTRAL WATERS[1,2]

By Ira D. Van Giesen[3]

Apparently the best classification for the purpose of corrosion studies, divides waters into three groups, acid, neutral, and alkaline, respectively. The waters in the acid group are definitely acid in nature and might be called acid solutions. Likewise, the alkaline waters are true alkaline solutions. The *neutral* waters comprise all those not included in the other two groups, and vary from a very weak acid as indicated by a pH value of about 4.5 to a weak base as indicated by a pH value of 10. Therefore, neutral waters are not necessarily technically neutral, but comprise practically all natural waters; the range in hydrogen ion activity being between the pH values of 4.5 and 10.

The reason for this classification is found in the nature of the corrosion processes which change below a pH value of about 4.5 and above a pH value of 10, but which remain constant throughout the range between these two values. Water-works men will encounter only the neutral waters, since the acid and alkaline groups are found only in certain manufacturing operations such as metallurgical, oil refining, and industrial chemical processes.

pH VALUE

The designation of the classification of waters just given is by pH values, so that it is important to understand fully just what the term *pH value* connotes. The atomic theory of matter, which conceives every element to be made up of small particles of the substance in question incapable of further division and still be that substance, uses the term *ion* to represent an isolated atom, or group of atoms, carrying one or more unit charges of positive or negative electricity.

[1] Presented before the California Section meeting, October 30, 1931.

[2] The following symbols have been used in this article with the meanings as shown. $<$, is less than; $>$, is greater than, $\rightarrow$, gives, or forms; $\uparrow$, passes off as a gas; $\downarrow$, precipitates; $\rightleftarrows$, dissolves, or, in solution; $\updownarrow$, dissolves and then precipitates. R^{++}, or, X^{-}, ionic R, or tonic X. Examples: Fe^{++} = ionic iron; OH^{-} = hydroxyl ion.

[3] Department of Water and Power, Los Angeles, Calif.

Those atoms carrying positive charges are called *cations* and those carrying negative charges are called *anions*. When a substance goes into solution it is believed to be more or less broken up into cations and anions. This dissociation of atoms from the molecule is called ionization, and the factor measuring this dissociation is called the *ionization constant*. The ionization constant for water (chemically pure), is 10^{-14}. Water dissociates into hydrogen cations and hydroxyl anions, and when pure the number of hydrogen ions is equal to the number of hydroxyl ions and the solution is neutral. Therefore, in a water solution the sum of the concentrations of hydrogen and hydroxyl ions, by definition, will always equal 10^{-14}, so if the hydrogen ion concentration is 10^{-4}, then the hydroxyl ion concentration must be 10^{-10}. These numbers are exponential terms for very small fractions. Thus 10^{-14} is the same as one divided by ten raised to the 14th power. Since these terms represent fractions, the smaller the exponent the larger the number, and consequently the greater the ion concentration represented thereby.

Dropping the negative sign, the value of the exponent of 10 which represents the hydrogen ion concentration is used to designate that concentration and is called the *pH value*. For every pH value there is a corresponding *pOH value* which is equal to 14 minus the pH value. Since every change in pH value is accompanied by a corresponding change in the opposite direction in pOH value, only one system of units is necessary to designate the intensity of both acids and alkalies.

It is essential to remember that the pH scale is a logarithmic scale, so that the ion concentration varies by a factor of 10 during a change of one unit of pH value. This is made clear in figure 1.

THE ELECTROMOTIVE SERIES

Every substance, i.e., element, exhibits a tendency to go or to keep from going into solution. This tendency is electrical in its nature and sets up an electromotive force, the magnitude of which depends on the element itself and the counter electromotive force set up by the ionization of the substance already in solution. Such a relationship gives rise to a series which is called the *electrochemical series*. The series is usually based on the descending values of this electromotive force i.e., the solution pressure, referred to hydrogen. (See table 1.) The series runs from a maximum positive value for potassium through zero for hydrogen to a maximum negative value for oxygen. This means that in an aqueous solution in which there is no tendency for

hydrogen to further dissolve, each element in the series having a positive solution pressure will require a counter electromotive force

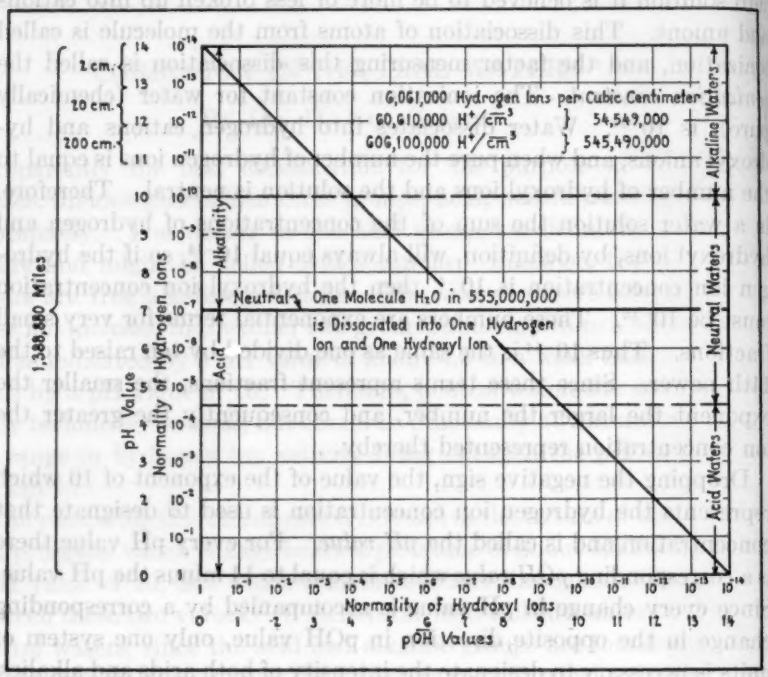


FIG. 1

TABLE 1

Electro-chemical series (solution pressure in volts referred to hydrogen)

Potassium	K	2.9	Lead	Pb	0.148
Sodium	Na	2.7	Hydrogen	H	0.000
Calcium	Ca	2.6	Copper	Cu''	−0.336
Magnesium	Mg	1.6	Copper	Cu'	−0.510
Aluminum	Al	1.276	Carbon	C	
Manganese	Mn	1.075	Boron	B	
Zinc	Zn	0.770	Chromium	Cr	
Iron	Fe'''	0.340	Chlorine	Cl	
Nickel	Ni	0.228	Sulphur	S	
Tin	Sn	0.192	Oxygen	O	

impressed from an external source of the magnitude of its solution pressure to prevent the element from going into solution. Like-

wise, an element having a negative solution pressure will require an electromotive force equal to its solution pressure to make it dissolve in that solution. Consequently in such a solution an element having a positive solution pressure tends to go into solution while one having a negative solution pressure tends to precipitate.

Any element under proper conditions will precipitate any other element which lies below it in the series from solutions of the compounds of the latter. Therefore, hydrogen will be released from solutions of its compounds by those elements which lie above it in

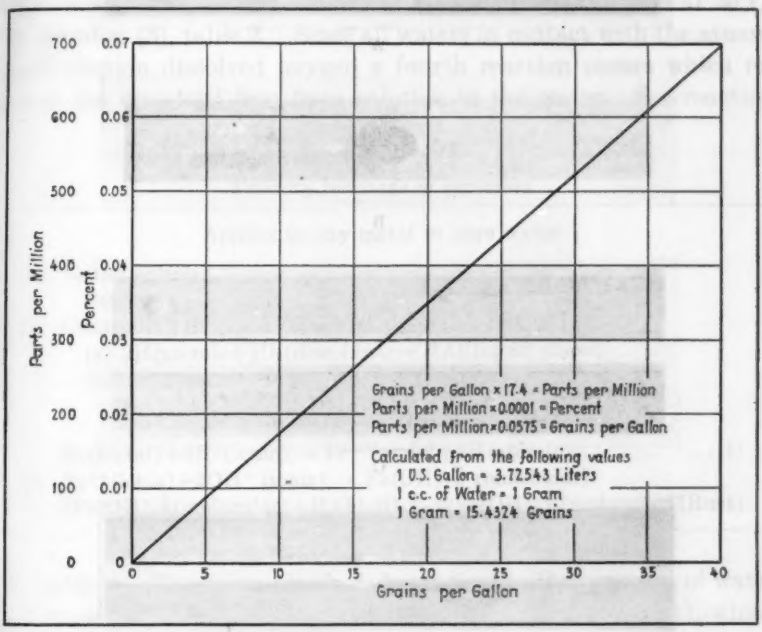


FIG. 2

the electrochemical series. Water is a compound of hydrogen, and the release of hydrogen therefrom with the concomitant dissolving of the metal in contact with the water comprises the phenomenon of corrosion. The element most involved in this process,—as far as water-works is concerned,—is iron.

REACTIONS IN CORROSION

With this basis laid it is now possible to formulate the chronological reactions of the phenomenon of corrosion. Chemically pure water is

ionized to the extent that one molecule in every 555,000,000 dissociates into its constituent hydrogen and hydroxyl ions. When any metal above hydrogen in the electrochemical series comes in contact with water the metal goes into solution as cations. These cations acquire positive charges from the hydrogen ions which give up their electrical charges to become atomic in form. Either or both of two

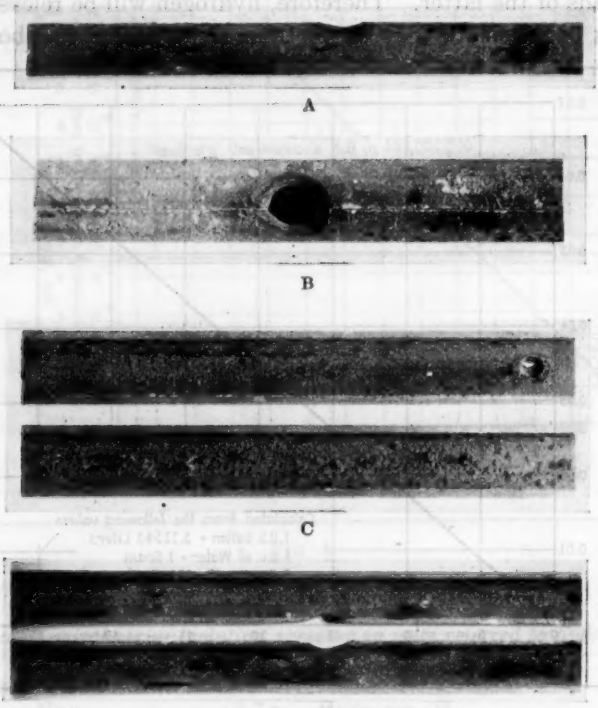


FIG. 3. A. Scale on outside of immersed hot water pipe. B. Hole in side of immersed hot water line. C. Scale on inside of cold water service pipe. D. Scale on inside of immersed hot water pipe.

things can occur to these hydrogen atoms: (*a*) they may unite with dissolved oxygen to form the liquid phase of water, and/or, (*b*), they may acquire energy from some source within the solution to form molecular hydrogen and pass off as a gas. In the absence of dissolved oxygen and a source of internal energy, reaction (2) could not take place, and reaction (1) would continue only until the osmotic pressure

of the cations in the solution equaled the solution pressure of the metal in contact with the water. The continuation of corrosion and its rate depend whether or not reactions 2, a and/or 2, b take place and the rapidity with which they are continued. These reactions apply to the corrosion of any metal in the presence of water.

In considering iron there are two other reactions which take place in natural waters free from dissolved salts, and which affect the total amount of corrosion. The cations of iron formed under equation (1) react with the hydroxyl ions to form ferrous hydroxide which dissolves in the water to the extent of but 6.7 parts per million at 20°C. See reaction (3), table 2. Since all waters in contact with the atmosphere contain dissolved oxygen a fourth reaction occurs which removes the dissolved iron from solution in the water. See reaction

TABLE 2

Primary reactions of corrosion

Applies to any metal in pure water
(1) Initial action
$R(metal)+H^+(ionic)\rightarrow R^+(ionic)+H(atomic)$
(2) Controlling or rate-setting reactions
(a) $2H(atomic+\frac{1}{2}O_2(dissolved)\rightarrow H_2O(liquid\ phase)$
(b) $2H(atomic)+Energy \rightarrow H_2\uparrow (molecular\ i.e.\ Gas)$
Applied to iron
$Fe(metal)+2H^+(ionic) \rightarrow Fe^{++}(ionic)+2H(atomic)$.....(1)
(3) $Fe^{++}(ionic)+2OH^-\ (ionic) \rightarrow Fe(OH)_2\lesssim\ (molecular)$
(4) $2Fe(OH)_2\lesssim(molecular)+H_2O+\frac{1}{2}O_2\lesssim\rightarrow 2Fe(OH)_3\downarrow (molecular)(Rust)$

(4), table 2. The ferrous hydroxide oxidizes in the presence of water and oxygen dissolved therein to form ferric hydroxide (rust), which precipitates and tends to form a loose scale on the surfaces of the iron where corrosion is not in progress, i.e., the cathodic areas. Reaction (4) reduces the osmotic pressure of the water on the iron by reducing the ferrous ion concentration, but at the same time the dissolved oxygen content is reduced so that the rate of corrosion tends to diminish, and if there is no source of oxygen supply the total corrosion is reduced.

The corrosion process, as it occurs in water-works practice, is greatly affected by the nature and the amounts of the dissolved salts found in all natural waters. These dissolved salts are usually the chlorides, sulfates, carbonates, and bicarbonates of sodium, calcium,

magnesium, and iron. Some of these salts undergo changes at relatively low temperatures while others remain unaffected. The bicarbonates decompose at the boiling point of water giving off carbon dioxide and forming the normal carbonates which, being insoluble,—with the exception of sodium carbonate,—precipitate forming a scale. Such salts are said to make the water temporarily "hard." The sulfates of calcium, magnesium, and iron are not affected at low temperatures and make water permanently "hard." Along with these salt impurities, all natural waters contain dissolved oxygen, carbon dioxide, and sometimes hydrogen sulfide, humic and oxalic acids.

SCALE FORMATION

Both temporary and permanent hard-waters are scale forming under certain conditions. Some scale is always formed by the rust

TABLE 3

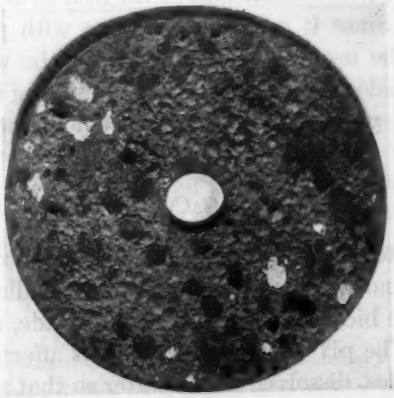
Corrosive reactions in hard waters

Temporary hardness
$Ca(HCO_3)_2 \equiv + Fe^{++} \rightarrow Ca^{++} + Fe(HCO_3)_2$
$Ca^{++} + 2H_2O \rightarrow Ca(OH)_2 \equiv + 2H^+$
$2H^+ + \frac{1}{2}O_2 \equiv \rightarrow H_2O$
$2Ca(OH)_2 \equiv + Fe(HCO_3)_2 \equiv \rightarrow 2CaCO_3 \downarrow + Fe(OH)_2 \downarrow + 2H_2O$
Permanent hardness
$CaSO_4 \equiv \rightarrow Ca^{++} + SO_4^{--}$
$H_2O \rightarrow H^+ + OH^-$
$Ca^{++} + 2H^+ + 2OH^- + \frac{1}{2}O_2 \equiv \rightarrow Ca(OH)_2 \equiv + H_2O$
$Fe^{++} + SO_4^{--} \rightarrow FeSO_4 \equiv$
$FeSO_4 \equiv + Ca(OH)_2 \equiv \rightarrow Fe(OH)_2 \downarrow + CaSO_4 \equiv$

itself, but rust scale alone is so porous that it gives small protection to the iron. In the presence of certain amounts of calcium salts, and/or silicates a thin protective scale will be formed on the surface of the iron which will greatly limit the supply of oxygen reaching the corroding surface thus greatly reducing and sometimes preventing further corrosion. Examples of corrosive and scale forming reactions in hard waters are given in table 3.

A very pure water chemically may cause more trouble than one containing relatively large amounts of certain dissolved salts. A water containing the usual amount of dissolved oxygen and no scale

A



B

C D

FIG. 4. A. Tubercles on inside of cast iron water main. B. Scale on inside of steel water main. C. Scale on outside of tubercle. D. Large tubercle from inside of steel water main.

forming salts will give "red water" trouble. If the calcium salts content is slightly increased the "red water" trouble may be stopped, but the tubercle-forming troubles may begin since a thin calcium carbonate scale may be sufficient to hold the rust in place on the corroding surfaces, but still be porous enough to permit corrosion to continue with the concomitant formation of large, flow decreasing tubercles. A further increase of calcium salts content can be made to stop both troubles.

In this connection the carbon dioxide content becomes important. Carbon dioxide, which when dissolved in water forms carbonic acid, i.e., common "soda water," does not of itself corrode iron, but it does govern the surface conditions of the iron so as to prevent or permit corrosion. Since it will do either one with perfect impersonal freedom it can be used as a mighty ally in the war against corrosion. This is made possible through the following reversible reaction which will take place at temperatures below the boiling point of water.

$$\text{(5)} \qquad Ca(HCO_3)_2 \rightleftarrows CaCO_3\downarrow + H_2O + CO_2 \rightleftarrows$$

Therefore, water containing calcium bicarbonate, as per equation (5), will or will not form a calcium scale depending on the relationship between the bicarbonate and carbon dioxide, and the pH value of the water. The pH value of the water is affected by other salts, especially chlorides, dissolved in the water so that no absolute values for these three factors can be given which will apply to all waters. The equilibrium values must be found for the particular water involved. This can be done by determining the bicarbonate and carbon dioxide contents of the water in question and then allowing a quantity of the water to stand 24 to 72 hours in contact with chemically pure calcium carbonate ($CaCO_3$). During the time that the test water is standing in contact with the calcium carbonate it must be kept out of contact with air so that it will not absorb carbon dioxide from the atmosphere. After the required period of time the bicarbonate content is again determined. An increase in bicarbonate content will show that there is aggressive carbon dioxide present and the water is scale dissolving. A scale dissolving water keeps the iron surface clean and in easy access to the dissolved oxygen and, therefore, open to the maximum rate of corrosion regardless of the presence of scale forming salts.

Since calcium carbonate is soluble in cold water only to the extent

of 13 parts per million (at 16°C.), the following values may be used to determine approximately the condition of any natural water as to its scale forming or scale dissolving qualities. The values given are equilibrium values between the carbon dioxide and bicarbonate contents, and the pH value for a saturated solution of calcium carbonate. The salt and gas content values are in parts per million by weight. (Data by J. Tillmans.)

HCO_3	FREE CO_2	pH
<15	0	>8.3
100	<1.75	8.1
200	<9.25	7.8
300	<36.00	>7.3
>300	>40.00	>7.1

If the pH value of the water is less than that given in this table for the bicarbonate content indicated the water is scale dissolving. If the pH is greater than that given the water is scale forming.

Scale dissolving water should be given a lime treatment to remove the aggressive carbon dioxide and to bring the pH value of the water

TABLE 4

Lime treatment of hard waters

Removal of calcium bicarbonate and carbon dioxide

$$CaO+H_2O\rightarrow Ca(OH)_2\equiv$$
$$CO_2\equiv+H_2O\rightarrow H_2CO_3$$
$$Ca(OH)_2\equiv+H_2CO_3\rightarrow CaCO_3+2H_2O$$
$$Ca(HCO_3)_2\equiv+Ca(OH)_2\equiv\rightarrow CaCO_3\downarrow+2H_2O$$

Removal of magnesium salts

$$Ca(OH)_2\equiv+Na_2CO_3\equiv\rightarrow 2NaOH\equiv+CaCO_3\downarrow$$
$$Mg(HCO_3)_2\equiv+4NaOH\equiv\rightarrow Mg(OH)_2\downarrow+2Na_2CO_3\equiv+2H_2O$$
$$MgSO_4\equiv+2NaOH\equiv\rightarrow Mg(OH)_2\downarrow+Na_2SO_4\equiv$$

Coagulum precipitation

$$Al_2(SO_4)_3\equiv+3Na_2CO_3\equiv+3H_2O\rightarrow 3Na_2SO_4\equiv+2Al(OH)_3\downarrow+3CO_2$$

to a point just above that of equilibrium. If the pH value is raised too high excessive scale may be formed and the flow in small pipes may be greatly diminished. The correct procedure can be determined only by accurate chemical control, with the idea of first form-

ing a close, thin, protective scale and then maintaining the pH at such a value that the scale will not be redissolved nor much increased. Since the carbon dioxide content usually varies with the seasons, automatic control of the lime treatment to maintain a constant pH value is essential. The chemical reactions involved in the lime treatment of waters is given in table 4.

The coagulum precipitation method of clarifying water always impregnates the water with carbon dioxide. This sends the water into the distribution system in an aggressive condition and usually results in severe corrosion. Almost all such treated waters should be given the correct lime treatment before entering the distribution system.

THE SPRINGTON DAM AND RESERVOIR[1]

By H. S. R. McCurdy[2]

The Philadelphia Suburban Water Company furnishes the water supply for the suburban territory adjacent to the City of Philadelphia, comprising an area of 300 square miles and containing a population of 350,000.

The source of supply is surface waters from streams sufficiently remote from congested areas to be free from pollution. The water is impounded, coagulated, filtered and pumped into distribution.

The system contains 4 pumping stations, 6 distributing reservoirs and 14 standpipes. Transmission and distributing mains are of diameters ranging up to 30 inches and aggregate 1000 miles.

There are three impounding reservoirs, containing $4\frac{1}{2}$ billion gallons. Two of the pumping stations have intake dams with practically no available storage. The standpipes and distributing reservoirs hold 25 million gallons of elevated storage, feeding into the system by gravity.

The average daily pumpage for this year to the end of October was slightly in excess of 20 m.g., with a daily maximum of $26\frac{1}{4}$ m.g.

The northerly portion of the territory receives its supply from the Neshaminy Creek and from the Pennypack Creek; the westerly portion from the Pickering Creek; and the southerly portion from the Crum Creek. The various supplies are interconnected, affording a measure of flexibility of operation as between the several plants.

In order to provide for future demands, an additional impounding reservoir on Crum Creek was created by the construction of the Springton Dam.

The Springton Dam is located in Delaware County on Crum Creek, about 8 miles from its confluence with the Delaware River and 7 miles west of the Philadelphia Line. The reservoir is 3 miles long and will impound 4 billion gallons. The area of water surface is 391 acres. The maximum depth is 66 feet, with an average depth of 31 feet.

[1] Presented before the 4 States Section meeting, December 11, 1931.

[2] Chief Engineer, Philadelphia Suburban Water Company, Bryn Mawr, Pa.

FIG. 1. MAP SHOWING CHARTER TERRITORY OF THE PHILADELPHIA SUBURBAN WATER COMPANY BOUNDED BY SOLID BLACK LINES

The watershed area above the dam is 21.5 square miles and at the pumping station 28.5 square miles. The stream is developed for a yield of 20 m.g.d.

Geological investigations at the dam site showed ledge rock at depths varying from out-crops to a maximum of 25 feet below the surface. The rock is a mica schist of various degrees of hardness, but in all cases sufficiently sound to furnish a satisfactory foundation for the masonry structures. An unusual feature of this rock is that it has a dip of about 60 degrees downstream. The planes of stratification are in close contact and afford no apprehension as to the water-tightness of the rock, considering the depth to which the core wall was carried and the fact that the rock beneath the core wall was grouted.

The overburden is a well graded material formed from the disintegration of the rock substructure. Across the valley bottom, adjacent to the stream, are various depths of alluvium, highly impervious. There were the ruins of a mill dam a couple of hundred years old on the site and upstream from this were deposits of silt, some of which it was deemed advisable to remove before placing the embankment.

The Springton Dam is an earthen embankment with a concrete core wall extending to solid ledge rock. The upstream and the downstream slopes are rip-rapped with rock fill. The total length of the dam, including the spillway, is 2,000 feet. The maximum height above the deepest portion of the core wall is 95 feet and the height of the dam above the general valley floor is 70 feet. The dam contains 483,000 cubic yards of rolled earth embankment and 73,000 cubic yards of rock fill.

A relocated state highway crosses the valley on the top of the dam and the seemingly excessive top width of 40 feet was dictated by the requirements of the Highway Commission, rather than by any question of stability. Similarly, the easterly end of the dam is curved into the hillside on a six degree curve to accommodate the alignment of this highway.

Below the flow line the upstream slope is 1 on 3. For protection against wave wash and ice and to render the slope stable in a condition of saturation under a falling reservoir, the earth embankment was faced with a rock fill. That portion of the upstream slope between an elevation 10 feet below normal flow line and the top of the dam is further protected with dry rubble paving, 2 feet thick, laid up by hand and closely bedded.

FIG. 1. MAP SHOWING CHARTER TERRITORY OF THE PHILADELPHIA SUBURBAN WATER COMPANY BOUNDED BY SOLID

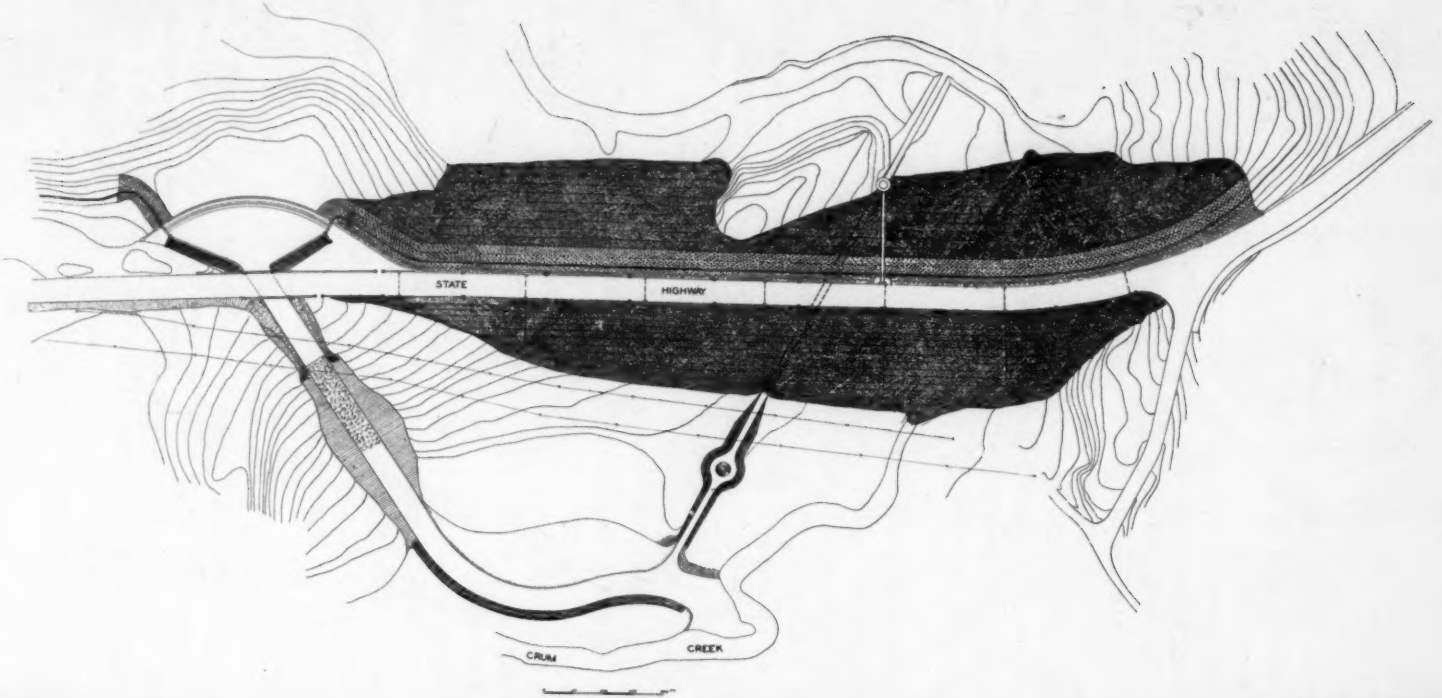


FIG. 2. GENERAL PLAN OF SPRINGTON DAM

The downstream slope of the earth embankment is 1 on 2, outside of which is rip rap 1 foot thick down to an elevation 27 feet below the top of the dam. Below this point the rock assumes a slope of 1 on $2\frac{1}{2}$, affording a constantly increasing thickness of rock fill as a protection against sloughing, should the downstream portion of the dam tend to become saturated.

The core wall is located on the line of the upstream shoulder of the dam, providing an impervious diaphragm against the seepage of water into the downstream portion of the embankment. This location of the core wall enables it to be used as a foundation for the masonry wall bordering the highway on top of the dam, furnishing an additional measure of protection against wave wash. Such arrangement has also the effect of increasing the freeboard of the dam.

The core wall is of plain concrete. The thickness at the flow line is 2 feet, with a batter of 1 in 40 on each side, giving a maximum thickness in its lowest portions of 6 feet. In general, the concrete was poured in sections 50 feet long and 10 feet deep, using steel forms. No attempt was made to provide water stops at the joints other than to use conventional keys in the forms.

Concrete was mixed in a central mixing plant located on the hillside at one end of the dam, adjoining the highway. The topography was such that the ingredients could be conveniently trucked to the plant. The stone and sand were elevated to an overhead hopper by means of a derrick and the arrangement on the hillside permitted a gravity flow down to the mixer. The mixer discharged through a chute into bottom dump buckets on a flat car. As the height of the dam increased, the chute was raised and a tower utilized to elevate the concrete to the chute. The car was hauled into place by a gasoline locomotive. Later trucks were used to transport the concrete buckets. The concrete buckets were lifted to the forms by a crane with caterpillar traction.

Particular care was taken to carry the excavation for the core wall sufficiently deep into the ledge rock to secure a foundation below the softening effect of surface deterioration. To do this, it was necessary in some cases for the trench to extend 15 feet into the rock.

As a precaution against the possibility of the seepage of water through the rock beneath the core wall, grout holes were drilled on 3 feet centers, alternating on an offset of 1 foot each side of the center line of the core wall. These holes were $2\frac{1}{2}$-inches in diameter and averaged about 20 feet deep. Tripod drift drills were found best

FIG. 2. GENERAL PLAN OF SPRINGTON DAM

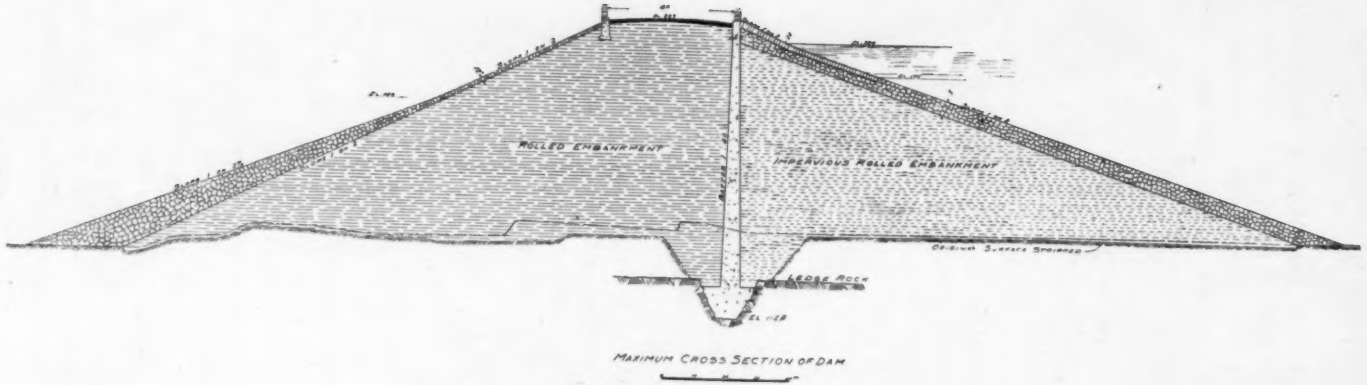


FIG. 3. CROSS SECTION OF SPRINGTON DAM

suited for this type of work. At the top of each drill hole a 3-inch iron pipe was sealed with cement and carried up through the first lift of concrete, for grouting. The concrete assured a seal on the top of the rock and prevented the grout from blowing out through any surface seams.

The grouting followed behind the concreting of the first lift, but was kept sufficiently back of the advancing core wall to prevent any grout blowing out of the ends of the trench. The grout machine was a standard air-agitated tank of 30 gallons capacity. The procedure was first to fill the holes with water and blow them out with air. Next a batch of grout was mixed in the proportion of 1 part cement to 8 parts of water, by volume, in order that this thin grout might flow freely and search out the furthermost cracks. In most cases this consistency of grout sufficed to fill the hole. However, when a hole would take grout freely, the consistency was thickened to 1 part cement to 4 parts of water and the hole grouted to refusal. In general, the pressure was 40 pounds, but often 50 pounds or higher were used in special cases. Occasionally, there would be communication between holes and several holes would be filled from one hook-up of the grout hose.

The borrow pits were located on both sides of the valley upstream from the dam. The material contained a well balanced distribution of fines, grading up to rock fragments so large that some of them would not properly roll into a 6-inch layer. These were culled out and cast into the rock fills facing the slopes. A typical analysis of material passing a 3-inch sieve was as follows:

Sieve inches	*Percent passing*
3	100.0
2	94.0
1½	90.3
1	88.8
¾	84.3
½	81.1
⅜	75.6
4	70.2
8	59.3
16	47.4
28	33.9
50	22.7
100	18.3
200	15.2

Specific gravity..... 2.65

The qualitative mineralogical examinations gave the results as shown below:

	percent
Mica	10
Clay substance	60
Sand	30

In addition to the foregoing examinations of the material, percolation tests were made in order to determine the degree of impermea-

FIG. 4. SPRINGTON DAM

Note: Gap is left in core wall for hauling materials

bility which might be expected. The results of these porosity tests were compared with tests similarly made on other dams which had been constructed.

Material from the borrow pits was excavated by means of two gas-air power shovels equipped with $1\frac{1}{4}$ yard dippers. Transportation to the dam was in bottom dump wagons, a six and an eight yard wagon to a train, hauled by a caterpillar "60" tractor. The maximum output of this plant was slightly in excess of 100,000 cubic yards per month for May, June and July 1930, working two 10-hour shifts. The material was dumped in longitudinal windrows and spread by

means of a tractor bulldozer into layers of a thickness which, after rolling with three-wheel, twelve-ton gasoline operated rollers, was compacted to 6 inches. Cleats were attached to the rear wheels of the roller to provide traction in wet weather. While material fresh from the borrow pits contained capillary moisture, it was necessary, during the greater part of the time, to operate watering carts in order that the material, at the time of rolling, should contain sufficient moisture to compact properly.

The portion of the core wall trench outside the concrete was refilled with fine earth deposited through water. This puddling process is effective in causing the earth to silt into all the crevices and seams and affords a means of insuring a compact earth embankment in areas too restricted or too irregular for rolling.

A concrete conduit, founded upon ledge rock, runs through the dam and served the purpose of taking care of the stream flow during construction. The conduit is 10 feet wide and 10 feet high and was figured to carry 100 c.f.s. per square mile of watershed area, running full. This capacity was considered sufficient insurance against the overtopping of the uncompleted embankment, in view of the fact that, as the height of the dam increased and overtopping became a more serious matter, the carrying capacity of the conduit, due to greater head, was correspondingly increased. Upon the completion of the dam the upstream portal of the conduit was sealed by a concrete plug in which was embedded a bellmouth casting forming the upstream end of the discharge pipe line. In order to carry the flow of the stream during the time when the plug was being constructed in the conduit, provision had been made in the form of a 36-inch reinforced concrete pipe by-pass controlled by a sluice gate.

At the upstream end of the conduit is a reinforced concrete intake tower, through which water can be taken from the reservoir at two different elevations and passed down to the stream below the dam through cast iron pipe laid in the conduit. In this pipe line near the downstream portal of the conduit is a control valve for regulating the discharge from the reservoir. Water from the intake tower to the pipe line can be shut off when necessary with a 48-inch sluice gate, operated from the floor at the top of the tower. Provisions were made in the intake tower, by means of grooves in the concrete, for lowering stop shutters, in order to blank off either or both openings into the tower and also the special casting at the upstream end of the pipe line.

A suspension bridge provides access from the roadway on top of the dam to the floor of the intake tower.

At the lower end of the pipe line is an aerator in the form of a masonry cone with stepped slopes, down which water is cascaded when aeration is desirable.

The spillway is located at the west end of the dam and its location and alignment were dictated by the configuration of the rock formation in the hillside at this place. The spillway is 300 feet long and in the form of an arc of a circle, discharging into a channel with rubble masonry walls and concrete paving. The upstream portion of the spillway is carried deeper into the rock forming a cut-off wall which is a continuation of the core wall of the dam. The discharge channel from the spillway passes beneath the state highway and is carried well below the dam, at which point the water is allowed to cascade down the hillside into the stream in a channel excavated mostly in rock, but without masonry protection. The capacity of the spillway, with water at the level of the crest of the dam, is 1000 c.f.s. per square mile of watershed area.

Excepting where the question of strength dictated otherwise, rubble stone masonry was used throughout the work in exposed faces. The cost was no greater than for plain concrete and the appearance is more in conformity with the rugged nature of the country.

The construction of the Springton reservoir necessitated the relocation of three highways. The state highway from Paoli to Media crossed the valley about 4000 feet above the dam. This was rerouted on top of the dam. Two township highways cross the site of the reservoir farther upstream and it was necessary to elevate these roads by means of fills and to construct a reinforced concrete bridge on the line of each road at the former stream bed.

The construction work was actively started in November, 1929. During the first winter the conduit was built, a large portion of the core wall trench excavated and some of the core wall constructed. The embankment was practically all placed during the working season of 1930. The spillway and bridge were finished in the spring of 1931.

Impounding was started in February, 1931, and was controlled at such elevation as not to submerge the highways crossing the basin upstream from the dam.

The relocation of these highways was completed in November, 1931, to a point where full storage in the reservoir was made possible.

INSTRUMENT AND CONTROL EQUIPMENT FOR AN ELEVATED STORAGE TANK[1]

By Homer Rupard[2]

The City of Indianapolis is served by two pressure districts. The high pressure district lies east of Keystone Avenue and Rural Street and includes the section known as Irvington. The district is normally served by the Fall Creek Pumping Station. Two electrically driven booster stations are provided to help carry the extreme rates demanded by the summer peak loads.

The design of the Irvington Tank installation has been covered in other papers and will not be touched in this discussion. The tank is a 1,500,000 gallon radial cone bottom tank, 97 feet and 6 inches to the top, and with a 25-foot depth of water.

When studies for the instruments and control equipment were started, a brief survey was made of tank installations in other cities. Detroit, Milwaukee and Columbus, Ohio, had recently completed installations of elevated tanks of, from one to two million gallons capacity. Automatic control and instrument equipment had not been developed on these installations to meet the needs of the local situation.

The following set of conditions were set up as the aims to be met by the control and instrument:

1. The equipment must be automatic and require no attendance.
2. The tank must float on the distribution system to get the maximum service from the equipment.
3. The altitude valve operation must be uniform and always at the same point.
4. The pumping station operator must have a continuous picture of the tank's performance in front of him.

The instrument and control equipment for the tank is housed in a structure at the base of the riser pipe. The 24-inch supply line passes through the basement of this structure. The equipment

[1] Presented before the Indiana Section meeting, March 9, 1932.

[2] Principal Assistant Engineer, Indianapolis Water Company, Indianapolis, Ind.

consists of three major items: (1) the altitude valve control, (2) the automatic heating equipment and (3) the tank level transmitting device.

ALTITUDE VALVE

The altitude valve is a hydraulically operated automatic cone valve. The four-way control valve is operated by a solenoid. A mercoid pressure switch, connected to the street side of the altitude valve opens the electric circuit to the solenoid when the tank fills to a predetermined point, de-energizing the solenoid and closing the altitude valve.

The mercoid switch is set so that it will not reclose the circuit to open the altitude valve until the pressure on the street side drops about 7 pounds below full tank pressure. To eliminate surges in the distribution system, the discharge from the hydraulic cylinder is throttled so that three minutes are required for the valve to open or close.

After the tank was placed in operation it was found that the mercoid pressure switch would not close the altitude valve at the same point every time. A variation of from 1 to 2 feet in the full tank level was found. Since the depth of the tank is only 25 feet, it is important to have the full point as near the overflow as possible to utilize the full capacity of the tank. A special switch was designed to operate from the level transmitter mercury float, which closes the altitude valve with a variation of not more than three inches in the full tank level. This switch is connected in parallel with the mercoid pressure switch.

HEATING EQUIPMENT

The heating equipment for the structure consists of six 500 watt electric space heaters, mounted in pairs. Each pair is controlled by an individual thermostat. The three thermostats are set to maintain a temperature of not less than 35 and no more than 45°F. in the structure. The structure was carefully designed and built to minimize heat losses. The heaters are mounted near the wall piping connecting the instrument and control equipment.

TANK LEVEL TRANSMITTING DEVICE

The tank level transmitting device consists of a current balance type of transmitter and a receiver operating over a two-wire circuit.

This type of transmitting device was selected because the apparatus is simple, as free as possible from moving parts, and made up of units which can be easily replaced. Furthermore, such a device is not affected by ordinary changes in the supply voltage or line resistance.

The transmitter consists of a primary meter, a transformer which supplies the plate and grid circuits or a set of ordinary three element vacuum tubes and a standard d'Arsonval type element which in co-operation with the primary meter translates the position of the prime mover into a proportional value of direct current.

The prime mover or primary meter in this case, is a mechanical lever device transforming the rotary motion produced by a float operated pulley into the angular movement corresponding to that of the secondary or sending element. The float is actuated by a special mercury column designed to give a positive and unchanging indication of water level.

The receiving meter is of the recording type and located in the Fall Creek Pumping Station. The pole line distance between the tank and the station is 11 miles and the resistance of the circuit is approximately 2000 ohms. The receiving meter is operated over a pair of wires leased from the telephone company. The major portions of the circuit are in cable pairs.

The receiving meter of the water level transmitter is a standard chart recording milliampere meter, calibrated in feet of water. Fifty milliamperes is the full scale value equivalent to 25 feet of water in the tank.

The graphic record produced by the receiving motor provides accurate information at all times as to the supply of water in the tank as well as a permanent record of the rate at which the tank is filled or emptied. A colluloid diagram is mounted on the front of the meter over the chart so that the station operator may determine the rate of filling or emptying of the tank in millions of gallons per day. By inspection, the rate line which more nearly corresponds to the line on the record, can be obtained and the pumping rate regulated accordingly.

In order to record the opening or closing of the altitude valve at the pumping station, another control is provided over the level transmitting circuit, i.e., the mercoid pressure switch has two tubes or contacts, one of which controls the altitude valve solenoid circuit and the other one is connected so that it will cut in an additional resistance of some 400 ohms in the telephone circuit when the mercoid

switch throws to the closed position. The cutting in of this additional resistance causes the transmitted current to drop sharply about five milliamperes, and then recover immediately as the current balance feature of the transmitter adjusts the transmitted current to the proper value. This action gives a single downward dip of the pen on the receiver chart. When the altitude valve opens, the mercoid switch shuts out this extra resistance and the recorder pen swings upward on the chart an equal amount. This signal feature has proven very useful in the operation of the tank.

A separate contact making receiving instrument is installed to light warning lamps at full and empty points of the tank.

The design was made and the installation supervised by the writer under the direction of W. C. Mabee, Chief Engineer. Mr. H. S. Morse is General Manager of the Indianapolis Water Company.

The equipment was furnished by the following manufacturers: Tank, Chicago Bridge and Iron Works, Chicago; Altitude Valve, Automatic Cone Valve Company, Chicago; Level Transmitter, The Esterline-Angus Company, Indianapolis.

WINTER OPERATION OF WATER WORKS SYSTEMS[1]

By J. Clark Keith

The greater part of the Dominion of Canada is in the colder temperate zone. At the extreme north, Arctic conditions prevail, while in Southern Ontario and Vancouver Island, the climatic conditions are those of the warmer temperate zone. In the main, the climate of Canada may be described as continental, that is, subject to extremes of heat in summer and cold in winter, but not generally prevailing on oceanic islands or on the sea coast in the same latitudes. At the same time a considerable area is comparatively near the sea, or adjacent to great bodies of water which have a tendency to modify temperatures, as for example, the peninsula of Southern Ontario or the coastal region of British Columbia. The comparatively high altitudes of the Prairie provinces are probably responsible for the strong cold winds which are a feature of the western winters. The southern portions of Ontario and Quebec are comparatively mild, but these provinces are subject to severe winters in the northern areas. Only in sections bordering Lakes Erie and Ontario and on the St. Lawrence is the normal mean temperature in July over 70°. In the Maritime provinces the climate is characterized by more equable temperature than in Ontario. The Southern part of Nova Scotia is the only part of Eastern Canada where the mean normal temperature in January is above 25°.

With this tremendous variation existing within the Dominion, it is obviously impossible to generalize when dealing with the effects of frost on waterworks construction and operation. The Canadian Section of the American Water Works Association is representative of Canada as a whole and not of any particular province. Consequently there must be a tremendous diversity in winter operating problems. A satisfactory solution to the difficulties in Essex County would probably invite diasaster 100 miles north. With the perpetually frozen soil which exists at Churchill, the terminus of the Hudson Bay Railway, a radical departure is necessary, even when compared

[1] Presented before the Canadian Section meeting, March 11, 1932.

with the methods adopted to withstand the rigors of the prairie provinces.

The Manual of the Water Works Association deals with standard and accepted practice in water works construction and operation. Its brief references to frost conditions are limited to hydrants and house services. The collaborators of the Manual may have decided, and quite properly so, that local frost intensities would govern the practice for that particular community or area. Many of the contributions appearing in the JOURNAL on this subject in recent years have been the outcome of Canadian experience as presented by members of the Canadian Section. These contributions would provide a very valuable and useful chapter if compiled and included in the Manual.

The problems of frost are not new. Frontinus was water commissioner of Rome A.D. 97. His history of the water supply of that city is one of the classics of waterworks literature. Although the system was constructed and operated under conditions more favorable than would prevail in almost any part of Canada, Frontinus has shown an appreciation of the effects of the elements on water works structures. "As a rule," he states, "those parts of the aqueducts which are carried on arches or are placed on side hills and, of those on arches, the parts that cross rivers suffer most from the effects of age or the elements. Therefore, must these be built with special diligence. The underground portions not being subjected to either heat or frost are less liable to freezing. . . . . Moderate weather is necessary for masonry to absorb mortar, for the heat of the sun is no less destructive to masonry than is too violent frost. . . . . The mere expansion and contraction of the stonework exposed to frost in the winter will speedily crack such masonry structures." This is the simple statement of an official of the first great water works system to be placed in operation.

The title of this paper is too comprehensive to permit of minute consideration of winter operating conditions on the various structures from intake to house service and meter. Within the past few years, papers on the insulation of water mains have been presented by W. E. MacDonald of Ottawa and E. M. Proctor of Toronto, while G. G. Routledge of Toronto and R. L. Dobbin of Peterboro have contributed to our fund of knowledge on the protection of exposed mains on bridges. The practice in many communities with respect to the protection and maintenance of hydrants, services and

mains has been fully and ably discussed at round table conferences. While there is an undoubted similarity in the troubles encountered, these are in degree rather than in kind.

In the Essex Border District it would be expected that troubles incident to winter operation would be much less acute than in many Canadian communities with temperatures as shown in table 1.

In the operation of the distribution system very little trouble from frost is experienced. Mains are laid with a 5-foot cover, while services are 4 feet deep. In the Walkerville-East Windsor System

TABLE 1

COMMUNITY	TEMPERATURES, DEGREES FAHRENHEIT			ANNUAL SNOWFALL, INCHES
	Average maximum	Average minimum	Mean	
Windsor, Ont.	56	39	48	49.4
Victoria, B. C.	56	43	49	14.8
Vancouver, B. C.	56	42	49	30.1
Dawson, Yukon	33	13	23	54.9
Fort Norman, N. W. T.	30	10	20	36.8
Edmonton, Alta.	48	26	37	42.5
Calgary, Alta.	50	26	38	43.5
Regina, Sask.	45	21	33	24.4
Winnipeg, Man.	45	23	34	47.7
Sudbury, Ont.	49	27	38	63.2
Cochrane, Ont.	45	21	33	65.1
Ottawa, Ont.	51	32	42	96.4
Toronto, Ont.	53	36	44	66.0
Montreal, Que.	50	35	42	119.6
Quebec, Que.	47	30	38	126.7
St. John, N. B.	49	34	41	82.2
Halifax, N. S.	52	35	44	77.1
Charlottetown, P. E. I.	49	34	41	95.6

there is no record of a frozen main over a period of 28 years. With approximately 6,000 services in operation there are not more than five complaints per year from frost. There has never been a hydrant frozen at the shoe. A small quantity of dilute alcohol provides ample protection where the hydrant cannot be drained. Meters 2 feet below the ground surface in pits are rarely frozen. More meters are damaged by hot water throughout the year than by frost. In the Windsor system with over 12,500 services there has not been a frozen service this winter. Under normal temperature conditions about

fifteen would be reported each year. During 1931 there were only 100 frozen meters. This number is likely to be reduced with an improvement in the conditions under which certain meters were originally installed.

INTAKE TROUBLES

In keeping with the general experience on the Great Lakes and their connecting rivers, intake trouble has been experienced with frazil ice. The intake which furnishes water to this district is 4 feet in diameter with an 8-foot bellmouth fastened to a stone filled crib in 40 feet of water. The velocity of the Detroit River at the intake is about 1½ miles per hour. On four occasions since 1926, ice has formed in sufficient quantities to be a matter of concern in plant operation. When this condition occurs, the temperature is usually below 15°F. and is accompanied by a westerly or northerly wind of sufficient velocity to ruffle the Detroit River. Unfortunately, an ice cover is rarely maintained over the intake. Trouble is presaged by a steady lowering of water in the suction wells and by the formation of a thin sheet of opaque ice over the travelling screens. First indications are usually noted directly before sunrise when the temperature of a normal winter day reaches its lowest point.

The piping within the pumping station has been so arranged that it is possible to reverse the flow of the pumps and place the intake under pressure. When ice is forming on the intake, the plant is operated normally until such time as there is not sufficient water to meet the demand of the filter plant. When this condition occurs, the number of beds in service is gradually reduced as the available supply decreases. When this flow reaches a rate of 4 m.g.d. the plant is shut down and the intake placed under pressure. No action is taken until this minimum flow is reached as it is felt that sufficient pressure cannot be brough tto bear on the ice obstruction if the opening is large enough to permit more than that amount of water to enter or leave.

Following this reversal of pressure, relief has been invariably secured and ice in large quantities has appeared in the suction well and on the screens. These masses conform to the contour of the pipe and bear the impression of pipe joints and rivet heads.

FILTER PLANT OPERATION DIFFICULTIES

In winter filter plant operation there are certain changes which are coincident with low water temperatures. These will be very briefly enumerated.

Coagulation—From a great number of observations at this plant it is evident that winter floc differs from that prevailing with warmer water. It is smaller and more compact per unit of coagulant fed per unit of turbidity. Generally speaking, more care and attention is required in the feeding of coagulants during the colder months.

Chlorine—It is generally accepted that the chlorine demand of a raw water, all other characteristics being alike, decreases with a drop in temperature.

Filter beds—During winter filtration there is a definite release of air in the sand, gravel and underdrain system. Although this does not appear to affect the efficiency of the beds, it does represent a potential source of trouble during the backwashing of the filters. This air must be released slowly and carefully to prevent upheavals of sand. Some slight trouble has been experienced with ice forming in the sand bed on the exposed walls of the plant. Under more severe conditions elsewhere, this might tend to travel well into the bed or even into the underdrain system. Two plants have recently been placed in service at Joliette and Lachine, Quebec, by Messrs. Crepeau and Hunter. One of these has been insulated against frost while the other is without that provision. The operating experience of these two plants should be a matter of much interest.

Filter backwashing—Due to the increased viscosity of the water, a greater expansion of the sand occurs in the winter months. This may, or may not, be of importance to the operator, depending on the design of his particular plant. Sand expansion is a function of sand size, shape, specific gravity and water temperature. Changes in the first three are due to sand accretions while the last arises from seasonal change. It is important that sand expansion be accurately determined at regular intervals. This precaution must be exercised to prevent the loss of the finer top sand.

WATER MAINS

The transition from the horse-drawn to the motor age has to some extent influenced water works practice. In the City of Montreal, mains were formerly laid at a depth of 4 feet, which was considered sufficient owing to the protection of from 1 to 2 feet of snow on streets and sidewalks. Due to the almost complete removal of this snow, the center line of the mains has been lowered to a point 6 feet below the established grade of the street. This depth seems to be usual practice in Quebec. Where heavy snowfalls are the rule, as in

Northern Ontario and Quebec, there is not the same need for any greater depth of cover than in more southerly parts of the province. Of greater importance is the fact that the snow comes earlier, having regard not to the time of the year only, but to the incidence of low temperatures. In Southern Saskatchewan and Alberta, where there is not a great depth of snow, but where temperatures are low, mains are normally laid with a 9-foot cover. Even at this depth when not gridironed, they sometimes freeze solid. In these provinces it is not unusual to utilize the electric thawer in May, the frost still increasing in depth, although it is leaving the ground surface. Soil conditions and snow cover have a greater bearing on main depths than have winter temperatures. Some natural protection can be secured by laying mains on the north and east sides of streets. Circulation is probably the most important of all factors in cities because of the almost universal practice of removing snow. During the winter of 1928–29, the City of Leadville, Colorado, in the absence of the usual snow cover, connected one of their power house boilers to an 8-inch line and forced steam into the main until the temperature was raised well above the freezing point. Steam was injected until the water reached 40°F. and the process was repeated as often as necessary. Provision has now been made by which any one of their three boilers can deliver steam directly to the distribution system.

ELEVATED TANKS

The operation of elevated tanks in Canada, to even a greater extent than water mains, is governed by temperatures. In those structures snow protection is not a factor. They rather naturally divide themselves in two classes, those in Southern Canada as distinguished from the colder northern areas. In Southern Canada the small cast iron riser can be sufficiently frost cased and protected from freezing, especially in communities where there is at least a small amount of circulation in the system during the night. With the larger diameter steel riser, the tank can be kept in operating condition, although there will doubtless be a layer of ice form in extreme cold around the shell of the tank. In Northern Canada some means of heat must be provided whether the cast iron or steel riser is used.

The purpose of heat is not so much to provide a means of raising water temperature to keep it from freezing as to provide a means of circulation in the tank itself. A very small amount of circulation in a tank will keep it from freezing during the night. In municipal

tanks there is usually enough circulation in the day time to afford protection. If steam is available, the simplest way to provide heat is through a coil passing up through the frost casing into the bottom of the tank. This will protect both riser and tank. If a hot water heater is utilized, the human element immediately enters into the situation and there is the possibility that the heater may not be fired at the proper time. However, this is simply one of the many problems where this element enters into the operation of a water works system.

In any municipal system where there is an elevated tank it is most important that there be a continuous circulation in the riser during extreme weather. No difficulty will be experienced if sufficient supervision is given to the heating of the tank. If the water in the tank is maintained at relatively the same level, the formation of ice around the sides of the tank is not a very serious matter. This condition cannot of course be maintained in a great many instances, but during low temperatures it is advisable to maintain a constant water level so that if ice forms across the tank no damage is done to the tank steel by this formation of ice. In some instances false wooden roofs have been installed above the water surface to help retain heat in the water. This is not as efficient as a proper circulating system.

WATER SUPPLY AT CHURCHILL

In view of the increasing development in Northern Canada, Horace Greeley's advice might be modified to read "Go north, young man." If the younger generation of waterworks engineers takes this seriously, they may have to contend with difficulties similar to those encountered at Churchill. These are so unusual and so acute as compared with what we have formerly considered problems that they should be of interest, if only by way of contrast.

It has been fairly well established by experiments in Siberia that, wherever the mean annual temperature is several degrees below the freezing point, the soil is frozen to a great depth. The mean annual temperature at Churchill is below 20° Fahrenheit and in consequence of this the ground is perpetually frozen. From the middle of May to the first of October, the mean temperature is above the freezing point.

The average monthly temperatures at Churchill are about as shown in table 2.

The Department of Railways and Canals has drilled holes 100 feet through the soil to the rock and all the ground overlying the rock is frozen. To what greater depth than this the frost penetrates, is not known. In operating steam shovels in gravel pits at Churchill, it has been found that in summer the frost goes out of the gravel to depths varying from 3 to 7 feet after the moss is stripped from the pit. Where moss is not stripped off either clay or gravel, the ground under the moss covering thaws for but a foot or two.

There are some small lakes near Churchill about 6 or 7 feet deep. These lakes freeze to the bottom in the winter months.

The reason for this unusual condition is unknown to the Department of Railways and Canals. The ground surrounding the lake is

TABLE 2

Temperatures at Churchill—degrees Fahrenheit

January	−19	July	+53
February	−17	August	+52
March	−6	September	+41
April	+15	October	+26
May	+29	November	+7
June	+43	October	−10

frozen from ground surface to rock. With these conditions prevailing it was apparent:

(1) That no pipe could be buried underground in the usual manner and be kept in service without the application of a great amount of expensive heat.

(2) There was no ground flow or no surface flow of water for a great part of the year except in the rivers.

As a solution to the problem of securing a water supply, the Department of Railways and Canals decided to dig a reservoir deep enough and large enough to store sufficient water under the 7 or 8 feet of ice that would form on the surface, for the winter months when there would be neither ground nor surface flow. A pipe line has been constructed above ground level on small piles driven 6 to 8 feet into the ground in solid frost. This pipe is being covered with moss to a depth of 4 or 5 feet. By this method it is hoped to keep the pipe line open for a considerable period after heavy frost sets in and at least throughout the shipping period at Churchill. In all probability, the town itself, when it develops, will draw water from the

pipe line in heated boxes above the ground. If the pipe line fails to function in the winter months, the citizens will probably depend on melted ice cut in the lakes.

In the preparation of this paper, I wish to acknowledge information received from George Kydd, Resident Engineer, Hudson Bay Railway Terminals, Ottawa; from the Horton Steel Works, Fort Erie, and from W. S. Lea, Montreal.

TWENTY-FIVE YEARS IN RETROSPECT[1]

By F. C. Jordan[2]

The Indiana Sanitary and Water Supply Association, and its successor the Indiana Section, American Water Works Association, needs offer no apology for its past record, nor any apology for its continued existence. The Indiana Sanitary and Water Supply Association came into existence as the result of a conference of municipal and private owned plants of Indiana, with the State Board of Health, at Indianapolis, July 8, 1908, which conference was called by and held under the auspices of the Indiana State Board of Health.

We are now holding the twenty-fifth meeting of the Association, and it is fitting that we give consideration to its development and accomplishments and to outline, if possible, a tentative program which will make the Association even a greater power for good in Indiana.

It is apparent from a study of the sanitary development in Indiana that the years 1906 to 1908 witnessed the beginning of a campaign to provide better water supplies and sanitary conditions for our State. The Water Laboratory of the State Board of Health was established in 1906, and the first conference between the public and private water companies and the State Board of Health was held shortly thereafter. The Proceedings of the 1908 Conference carries a very interesting article by Dr. H. E. Barnard, then Chemist to the State Board of Health, in which he makes the following significant comments:

"Knowing then that many of our public supplies are already somewhat polluted, or are liable in the near future to become unfit for use, and that the private well supplies, of which there are more than 500,000 in the state, are in at least 50 percent of the cases already contaminated, the work of the State Board of Health in correcting present conditions, and in insuring the health of later generations becomes a task of great magnitude and inestimable value."

[1] Presented before the Indiana Section meeting, March 10, 1932.

[2] Secretary, Indianapolis Water Company, Indianapolis, Ind.

In the latter part of his address, Dr. Barnard said:

"When the people realize the economic cost of water-borne disease, when they understand that one death from typhoid fever costs the community more than pure water, when the city dweller can be made to appreciate the fact that the cesspool in the back yard becomes inevitably a source of water supply for his well, and when the country dweller learns that water from a surface well is dangerous, we may expect not only proper legislation, but contistent compliance on the part of citizens that will eradicate the scourge now imposed upon us."

The 1908 Annual Report of the State Board of Health shows that the Board made 190 analyses of water from public water supplies during that year, and the report contains the following warning:

"The continued use of shallow wells by city and town officials is a reproach upon our intelligence. The use of such wells should be forbidden by city authorities and connections to the mains of public water supplies forced if need be. It is as necessary to protect the people from the scourge of typhoid fever as to protect their homes from fire, or their property from the thief."

The deaths from typhoid fever in Indiana in 1908 numbered 885, the death rate per 100,000 population being 32.4.

As indicating the remarkable advancement, and as a proof of Dr. Hurty's claim that typhoid fever can be stamped out, the number of deaths from typhoid fever in Indiana in 1931 was only 98, giving a death rate of only 2.9 per 100,000 population. This rate certainly compares favorably with the rate of 32.4 in 1908, and stands as a fitting testimony to the invaluable services of men who visioned a clean state from which typhoid had been banished. Dr. W. F. King tells us that if the typhoid death rate of 1908 had prevailed during 1931, there would have been 964 more deaths from this disease than actually occurred. Estimating these lives saved at $5,000 each for adults, and $2,000 each for those under twenty years of age, the total saving in 1931 as compared with 1908 is $3,750,000.

The prevalence of typhoid fever is a fairly reliable indication of the group intelligence of a community as related to the care and safeguarding of its sanitary environment and of the protection of its water, milk and food supplies. The prevalence of diarrhoea and enteritis is a fairly reliable indication of the intelligence of family groups in a community as relates to sanitary matters, and indicates the degree of care or carelessness associated with the food and drink of its infant population. The records of the State Board of Health tell us that in 1908 there was a total of 2,189 deaths in Indiana from

diarrhoea and enteritis, or a death rate of 80 per 100,000 population. In 1930 the number of deaths from diarrhoea and enteritis in Indiana was 861, with a death rate of 26.9 per 100,000 population.

In the fiscal year of 1931 the laboratory of the State Board of Health examined 9,567 water samples from public water supplies and examined a total of 15,096 samples of all types of water supplies. Of the 9,567 samples examined from public water supplies 4.7 percent were classified as bad because of 3 or more positive portions of such samples containing B. coli. In commenting on the work of the State Laboratory the annual report of the State Board of Health says,—"More than half of the people of the State are served by or have access to a public drinking water supply. This population by no means represents the total number of people who could economically be served by public water supplies." But Indiana has made marvelous progress on the matter of public water supplies, the 140 plants of 1907 having been increased to 276 in 1931, a gain of almost 100 percent.

Indiana's marvelous record of disease prevention through sanitary development did not just happen. These conditions have come about because a certain group of men set themselves to the job of arousing the public to the importance of sanitary measures and have adherred steadfastly to that task. Let it be said to the credit of this Association that its membership and its Conventions have been a mighty force for good in the campaign to make Indiana a more livable state. Many of the members of the Association pioneered in matters of sanitation, and it is indeed unfortunate that some of them passed to their reward before Indiana reached the enviable position it now occupies of being either in Class One, or on the Honor Roll of the American Medical Association's Typhoid Roll.

Through the years the Indiana Sanitary and Water Supply Association, and its successor the Indiana Section, American Water Works Association, availed itself of the very best of talent in the fields of waterworks and sanitation. A mention of a few of these men will instantly call to our minds the outstanding service rendered by these men who gave papers before our Association, which not only did incalculable good for our state, but rendered almost equally valuable service throughout the major portion of our country. We are frequently prone to forget the services of men, especially those who are gone, but I desire here to record the names of some of the men who have helped to make our Association a great force for good:

John W. Alvord	Edward Bartow
George W. Booth	Charles B. Burdick
Philip Burgess	Severance Burrage
W. S. Cramer	W. W. De Berard
Joseph W. Ellms	Halford Erickson
George H. Fenkell	George W. Fuller
Samuel A. Greeley	Arthur E. Gorman
Clarence Goldsmith	Paul Hansen
Jack J. Hinman	Charles P. Hoover
George A. Johnson	Morris Knowles
Beekman C. Little	L. L. Lumsden
Dabney H. Maury	Leonard Metcalf
Dr. A. J. McLaughlin	W. F. Monfort
Langdon Pearce	W. D. Pence
Malcolm Pirnie	J. P. Simonds
Thomas J. Skinker	R. L. Sackett.

Record will also be made of some of our own Indiana men who have rendered fine service in connection with our Association:

J. N. Hurty	H. E. Barnard
Richard Lieber	Charles W. Fairbanks
W. E. Stone	W. K. Hatt
A. W. Potter	Thurman B. Rice
R. B. Wiley	

And also that group of waterworks men who have always been faithful to the best interests of the Association.

A review of the Proceedings will disclose a wealth of material covering every phase of sanitation and waterworks operation. A mention of a few of these papers will cause us to realize that our Association has ever been in the forefront in the campaign for better sanitation and better public water supplies.

In the year 1908, Drs. Eugene Buehler, H. E. Barnard and J. N. Hurty warned the people of Indiana that the private well and privy vault were sources of disease and that they must be stamped out if the state expected to rid itself of typhoid. In proclaiming this danger Dr. Eugene Buehler stated:

"In addition to having a driven well on the premises, there is also a privy vault usually within 25 feet, so constructed that it permits the vault contents to filter into the ground, making frequent cleaning of the vault unnecessary, and when I add to this that the City of Indianapolis has no Ordinance compelling sewer connections nothing further need be said of the possibilities of such a water supply."

At each succeeding Convention of this Association some authority sounded a further note of warning, but it was not until 1922 that the City of Indianapolis adopted an Ordinance which eventually will rid the city of these cess pools.

In 1908, F. A. W. Davis, Drs. Hurty and Barnard, and others, spoke of the Menace of Stream Pollution, and at succeeding Conventions the importance of the elimination of stream Pollution was repeatedly stressed by outstanding authorities, and much of the legislation adopted in Indiana was due to the perseverance of members of this Association.

In 1912, George A. Johnson, H. E. Barnard, R. L. Sackett, Langdon Pearse and George W. Fuller spoke through this Association on the importance of sewage disposal. These addresses, supplemented by those in subsequent meetings of this Association, had much to do with the formation and passage of our present Sewage Disposal Legislation.

In 1910, Severance Burrage and George A. Johnson presented valuable papers and discussion on the subject "Use of Hypochlorites in Water Purification," and paved the way for the general use of this adjunct to filtration. The closing words of Severance Burrage were prophetic: "From the nature of this experiment, and from the reports of experiments on sewage, and one or two water supplies where the hypochlorite is being used, the writer does not hesitate to prophecy that in the near future hypochlorite will be very extensively used in the purification of suspicious and polluted waters." In Mr. Johnson's discussion he states "As an adjunct to filtration, bleaching powder and hypochlorite of soda will undoubtedly be heard from to a great extent in the future."

At the 1908 meeting of the Association, H. E. Jordan presented a valuable paper on "Transmission of Typhoid Fever," a paper which did much towards correcting erroneous impressions in reference to this subject. In commenting upon the paper Dr. Hurty stated: "Mr. Jordan's paper is of greatest value. I do not believe a medical man in the State of Indiana could have presented it in a more original and eloquent way." Twelve years thereafter, Mr. Jordan gave a paper before this Association entitled "Fifteen Years of Filtration Practice in Indianapolis," and this paper likewise attracted wide attention.

More than twenty years ago Charles B. Burdick, Dr. J. N. Hurty, and others, gave papers before our Association in reference to the

"Value of Pure Water," and these papers had much to do with the development of good public water supplies.

In 1913, Richard Lieber presented before our Association a paper entitled "Fire Waste and Fire Prevention," and it was in all probability the best presentation of the subject up to that time. Mr. Lieber appeared on later programs, and his talks, together with those by George W. Booth, Clarence Goldsmith, J. B. Marvin, Howard Dill and others, have had much to do with building up the public and private fire protection service, not only throughout Indiana but throughout many other states of the Union.

In 1913, H. E. Jordan and others sounded a note of warning in reference to the danger of physical connections between public and private water supplies. Much has been written since that time, and much has been accomplished, but that question is of such importance today as to warrant its inclusion in today's program.

In 1909, Mr. W. C. Mabee, then Constructing Engineer of the Indianapolis Water Company, gave an interesting paper on Concrete Construction, the last words of his paper carrying a prophecy as follows: "I venture to predict that concrete construction is destined to take an important part in the purification of surface water supplies of Indiana in the years to come." The Proceedings carry many other papers by Mr. Mabee on this important subject and verify the predictions which he made at the second meeting of this Association.

Ten years ago Carl Wilde gave us an interesting paper on "Service as an Element in Rate Making," and implanted the thought that good service is deserving of its proper reward.

In recent years we have had some excellent papers on the subject of "Financing Plumbing on the Convenient Payment Plan," our Association having pioneered in this matter.

Messrs. George H. Fenkell, W. C. Mabee, and others, have in recent years given valuable papers on "Elevated Water Storage," and these papers have attracted international attention.

A recent paper, which is destined to attract marked attention, is the one given before our Association by H. S. Morse on the subject "A Water Company Rating Scale." It is my opinion that some such scale will ultimately be accepted practically upon a par with the Rating Scale adopted by the National Board of Fire Underwriters.

Our Association has made heavy demands on the time of some of its members, and a review of the Proceedings gives evidence of the exceptionally fine service rendered by a few of the men whom we

might designate as the "Old Faithfuls." Dr. W. F. King has been on the program 16 times; Dr. H. E. Barnard 15 times; Dr. J. N. Hurty, H. E. Jordan, Charles Brossman and Howard Dill, each 14 times; John W. Toyne 13 times; W. H. Durbin, Dow R. Gwinn, W. C. Mabee, each 12 times; J. B. Marvin, 10 times; C. K. Calvert, H. O. Garman, J. W. Moore, each 9 times; L. S. Finch, 8 times; J. A. Diggs, 7 times; E. L. Loomis and W. L. Younce, each 6 times, and the writer 14 times. Of the out-of-state men Dr. Bartow has been on the program 9 times; Severance Burrage and Prof. R. B. Wiley, each 7 times; George W. Fuller, Philip Burgess and Paul Hansen, each 6 times; Dr. L. L. Lumsden, Richard Lieber, Dean A. A. Potter and Professor R. L. Sackett, each 5 times; Leonard Metcalf, Clarence Goldsmith and Dabney H. Maury, each 4 times, etc., etc.

I am sure that I voice the sentiment of all members and friends of the Indiana Section, American Water Works Association, when I express sincere thanks for the fine services rendered by those men, who through this and kindred associations have done so much to make Indiana a better state in which to live.

In passing around the bouquets, there are two men to whom the choicest flowers should be given—Dr. W. F. King and C. K. Calvert. Presidents of Associations come and go, but it is fortunate that for us our Secretaries go on forever. Dr. King served as Secretary for six years, and C. K. Calvert has now served for twelve years, and no men in the Association are deserving of greater credit than are these two men. May their shadow never grow shorter.

During the years of existence of our Association, Indiana has enjoyed wonderful progress, and it can be said without fear of contradiction that our Association has had much to do with the betterment of the public water supplies and sanitary conditions. Dr. King has well stated that

"Sanitary protection and safeguarding of public water supplies is a fundamental and major activity in the field of public health. The accomplishments of sanitary engineering in the public health field stand out as one of the chief accomplishments of the past quarter of a century. But notwithstanding the beneficient results already accomplished, much remains to be done. So long as more than 50 percent of the people of the State of Indiana must depend upon water supplies from doubtful sources that are subject to pollution by human waste, just so long will threat of typhoid, intestinal infections and other waterborne diseases continue. As population increases, as it will; as ground water supplies continue to fail, as they will; as soil pollution and stream pollution

increases; as both are increasing under present conditions, eternal vigilance will continue to be the price that must be paid for even a reasonable protection of life and health and happiness against the dangers that lurk in and are carried by sources of water supply.

"The time has come when the people of Indiana must face the problem of soil pollution and stream pollution and the conservation and safeguarding of water supplies. Pollution of streams and lakes must be eliminated, not because of the value of streams and lakes for pleasure and recreation purposes, but because of the absolute need for all ground waters and surface waters as sources of water supplies. It will not be an easy problem to solve and the solution will be costly, but no matter what expenditure of intelligence, effort and money may by required, the expenditure must be made if safe and wholesome water supplies are to be assured and public health is to be preserved for the future."

Having in mind the making of our Association even a greater force for good in the future, some of our members were invited to suggest certain major activities toward which our Association should turn its energies to the ultimate benefit of our citizenship, and some of those suggestions are now submitted for your consideration and possible adoption.

TENURE OF OFFICE

The first suggestion has to do with tenure of office, and the following pertinent comment is in line with the general thought expressed on this subject: The primary need of water supplies in Indiana rests in the obtaining of intelligent supervision and management of its municipal water supplies, and when this intelligent management is obtained, the continuation of such personnel in those activities. No community in Indiana is so small or is its water supply problem so unimportant as to justify the handling of its water supply problems with anything less than the highest reasonable degree of intelligent control. Such control should not be vested in individuals whose selection for the task is accidental, nor should persons be removed from these activities and their replacement made as a means of payment of political debts. There are other public activities in Indiana where the value of training and service is recognized to the point that tenure of office is reasonably stable and removal effected only for cause. Such principles should be extended as rapidly as possible into the administration of public water supply works.

RAISING THE STANDARD FOR OPERATORS

The second is in reference to the raising of the caliber of water purification plant operators. It has been truthfully stated that this

can be accomplished by training the existing personnel and by making replacements with technical men. It is readily admitted that at the present time in the small towns of Indiana, it would be unheard of to have an outsider and a technical man in charge of the water plant. Nevertheless, this can be brought around in due course of time through proper publicity. It is suggested that this Association, Purdue University, and the State Board of Health, coöperate in putting on a school for waterworks operators to be held during the week preceding the annual meeting of the Association. Such a school should do much towards increasing the efficiency of the public water supplies of Indiana.

COMPLIANCE WITH ORDERS

The third suggestion is in reference to the full and reasonably prompt compliance with the orders of the State Board of Health, and other regularly constituted superior authorities. It can be truthfully stated that many of the water plants have complied with every major recommendation of the State Board of Health regarding the control of the water supply, but it is a regrettable fact that there are a number of conspicuous examples of plants claiming to be efficient in the operation of their affairs where orders regarding the improvement of the public water supply have been disregarded. This is a regrettable fact and one which should be taken to heart by those persons entrusted by their municipalities with the administration of public sanitary works.

ELIMINATION OF POLLUTION

The fourth suggestion has to do with the elimination of the pollution of streams and lakes, and the suggestion has been made that this Association exert its influence towards this important conservation of the water supply.

Many other suggestions have been made, but if our Association will adopt these suggestions as their major activities, and bring about their successful culmination, we will render an invaluable service of which we may feel justly proud.

BRILLIANT GREEN BILE FOR COLI-AEROGENES GROUP DETERMINATIONS

By H. E. Jordan[1]

The seventh edition of "Standard Methods for the Examination of Water and Sewage" will include the basic data for the laboratory worker to follow when using brilliant green lactose bile broth and lactose bouillon in water examination. While the procedure outlined indicates the use of the combination of materials only on waters in process of purification and the "Complete" test is still to be required on waters ready for public use, the insertion of the data in Standard Methods is at least a partial concession to the fact that selective media have a place in the water supply laboratory. The need for such methods has been cogently expressed by Prescott and Winslow in the fifth edition of "Elements of Water Bacteriology."

"It is the belief of the authors that the time has now come when the numerous methods, old and new, should be examined with the object of securing not only the greatest accuracy, but the most practicable simplicity, consonant therewith." "Accuracy of data, promptness in securing conclusive evidence, and simplicity rather than multiplicity of procedures are highly desirable." "As long as the present Standard Methods remain the established procedure .... they must be accepted and followed; for uniformity and comparability are the most vital essentials in any field of practical administrative laboratory control. The authors are strongly of the opinion, however, that the time is more ripe for a radical revision of these standard procedures."

Almost as soon as the colon group of organisms began to be given special study and significance in water examinations, efforts were made to develop media that would inhibit the other types of bacteria and favor the growth of coli. At the beginning of the century, phenol broth was frequently used. Numbers of other selective media have been proposed, studied, used and discarded.

The question naturally arises—what defects exist in the present

[1] Sanitary Engineer, Indianapolis Water Company, Indianapolis, Ind.

standard technique. The very great defect is the non-specificity of lactose broth fermentation on modern purified waters. If it were not desirable to have the first step in the routine isolation reasonably significant in the majority of water supplies, it might be satisfactory to consider lactose broth primarily as a rejuvenation medium. But the tendency on the part of health officers and laboratory workers is to interpret gas production in a fermentation tube as really significant of the presence of the coli-aerogenes group. Thus we have the anomaly of a material being used that, by the profusion of its positive reactions, casts doubt upon many water supplies, which doubt is not justified by later routine findings. As a working took in the hands of the plant operator, standard lactose broth has long been recognized as having little value. It lacks specificity. The reason has been amply demonstrated. Holman and Meekison (15), Leitch (28), and Sears and Putnam (40) have shown that the profusion of false presumptives in lactose broth is due to division of labor among the bacteria in the medium. One class of organisms has the power to break the lactose molecule into a simpler form and the other class of organisms has the ability to ferment dextrose. The first class has no fermentative power, the second cannot ferment lactose. But the two acting in succession and in the common environment produce the visible effects of the lactose fermenter. The effect of this characteristic of lactose broth growth is to produce in the first 24 to 48 hours of routine examination a large number of positive fermentations. Subcultures from these tubes frequently do not grow aerobically upon plates, frequently they do, but fail to produce secondary fermentation or are spore-forming organisms. The mass effect of the technique is to destroy the needed coördination of plant operation and laboratory findings. Six to seven days are required to produce a "complete" finding of coli-aerogenes group. Whatever value the finding them has is historical. The water has been used.

This state of affairs has been recognized by those who attempted to develop selective media. They desired to introduce into the technique at the command of the laboratory worker and plant operator, a medium whose initial findings were as prompt and specific as possible, a material that would truly produce a danger signal. It must be stipulated that there does not exist nor does it appear possible to develop a medium that will be at the same time both selective and catholic in its activity. The absolute attainment of one characteristic is at the expense of the other. In the brilliant

green bile studies the hope has been to develop a medium that would exclude the synergistic complexes referred to above by the adverse effect of the dye upon the Gram-positive organisms, and at the same time to use the concentration of bile most favorable to the coli-aerogenes type. The medium that has been developed and used according to the parallel planting technique appears, in the writer's opinion, to demonstrate 95 to 97.5 percent as many coli-aerogenes positives as the standard procedure. It is also the writer's opinion that the over-recording of coli-aerogenes by standard procedure due to the handling of mixed cultures is equal to or greater than the 2.5 to 5 percent difference above shown. The two methods in the long run probably check so far as bacteriological methods will ever check.

Brilliant green lactose peptone bile is not conceived by its proponents as the complete answer to the bacteriologist's prayer, but its historical background is ample and the rationale of its use intelligent. In its present form in addition to 1 percent peptone and 1 percent lactose it contains 2 percent ox bile and 0.00133 percent brilliant green. Its development is the blended outcome of two separate lines of study.

The use of the bile was first presented by Jackson (17) in 1906, although his work was suggested by earlier work of MacConkey involving the use of purified bile salts such as sodium taurocholate. As first developed by Jackson, the fermentation tube medium was fresh undiluted ox bile to which 1 percent lactose was added. In 1910 Jackson and Muer (18) developed liver broth in which 50 percent beef liver infusion was used instead of the fresh bile and dextrose substituted for lactose. This medium became standard in the 1912 edition of Standard Methods. A number of studies were made indicating that this medium was not alone inhibitory to non-coli organisms but also to the colon group. The most frequently quoted study is that of E. O. Jordan (19) who concluded that lactose bile inhibits from one-third to one-half of the viable cells of B. coli." It is vital at this time to point out that the above study was made with the Jackson lactose bile, i.e., pure sterilized bile to which 1 percent lactose had been added. That is an entirely different material from the present combination which contains one-fifth as much bile. While bile media were dropped from the 1917 edition of Standard Methods, studies as to their value continued. One that unfortunately has been frequently overlooked was made by Levine (28). He showed that the conflicting views as to value of bile media could be reconciled by a

study of the concentration at which growth of coli or aerogenes was favored or inhibited. The results of his study were, briefly, that concentrations of 10 per cent or more bile were inhibitory; that coli grew best in the presence of 2 percent bile,[2] and that aerogenes grew best in the presence of 1 percent bile. Within these ranges of bile concentration the growth of both coli and aerogenes was accelerated, anaerobic spore-forming lactose fermenters were inhibited and aerobic sporing lactose fermenters did not grow.

The use of brilliant green and its prototypes of the Tri-phenyl-methane series takes origin in the studies of Churchman (3–4) in 1912 on gentian violet. Further studies by Kligler (22) and Krumweide and Pratt (23–24) developed data that may be summarized as follows: The tri-phenyl-methane dyes are toxic to bacteria. In general they restrain the growth of Gram-positive bacteria and have no effect upon the Gram-negative group. The different dyes in the group possess similar selective action, but the concentration at which they are most effective varies. The first application of these dyes to water examination was made by Hall and Ellefson (13) in 1916. They used a 1 percent lactose broth to which gentian violet was added in a 1:20,000 concentration. While this concentration of gentian violet did "eliminate spurious presumptives for B. coli," it also was subject to the same objection that affected the original lactose bile, i.e., it prevented the growth of coli in a reasonably large number of cases. Later in 1918 Muer and Harris (30) developed a 1:10,000 brilliant green 5 per cent bile, 1 percent lactose, 1 percent peptone broth and compared it with the Hall gentian violet lactose broth as well as standard lactose broth with favorable results. The paper detailing these results was not published until November, 1920, and use of the medium outside the laboratories of the New York City water supply laboratories spread slowly.

In 1923, Committee No. 1 of the American Water Works Association assigned study of the medium to M. H. McCrady (7). He and a large group of associates used the Muer and Harris medium in examination of waters in many parts of North America. Over 4000 presumptives studied showed that in 91 percent of the cases where coli was shown after the use of standard lactose broth, it was also demonstrated by original planting in brilliant green bile. There quickly followed reports on work done by Jordan (7–20) Howard

[2] Hereinafter the word "bile" will be used to designate "dry ox bile."

(16), Lauter (25) and Ruchhoft (37). Dunham and Schoenlein (6) in 1925 made a careful study to determine the optimum conditions as to bile concentration, brilliant green concentration and hydrogen ion concentration when working with pure strains of coli. Their results were: Greatest stimulation of coli occurred in media containing 2 percent bile, lesser stimulation down to 1 percent and up to 3 percent. Concentrations of 4 and 5 percent bile gave variable results. With 2 percent bile the maximum favorable density of brilliant green was 1:75,000. With 5 percent bile the maximum density was 1:10,000 In 2 percent bile media the optimum pH was 6.9 and in 5 percent bile media −7.1. Ruchhoft (38–30) in 1931 has shown that 2 percent bile media may be buffered and the pH raised to 7.6–7.8 with the result that the material becomes less inhibitive and correlatively less selective. Stearn and Stearn (41) and Rakieten and Rettger (35) have in earlier work shown that the inhibitive effect of brilliant green upon gram-positive organisms diminishes rapidly as the pH is raised above 7. It seems proper to conclude that if the selective value of the medium is important, nothing is gained by increasing the pH.

During 1925 and 1926 fifteen laboratories coöperated under the direction of the writer (20) in studies of the comparative results obtained with 5 percent and 2 percent bile used both as an original planting medium and as a secondary medium. There were, from a large number of original plantings, 784 "complete" coli-aerogenes findings according to standard methods. No effort was made to check the correctness of these completions, although it has been recently demonstrated by Ruchhoft (38) that when standard methods are used, the tendency is to find more "complete" coli than are actually present. The comparative studies with the use of primary or secondary planting into 2 percent bile 1:75,000 brilliant green lactose broth resulted in the finding of 762 cases of fermentation of the broth in 48 hours and 744 completions therefrom. The respective ratios, with lactose broth completions taken as 100 percent, were 97.2 percent correlation upon the basis of green bile broth fermentation and 95 percent correlation of the subsequently "completed" cultures. In only 0.2 percent of the cultures were spores found. Since that work was reported, studies of differential media have been made by Poe (33–34), Ruchhoft (39) and others and the parallel planting technique has been developed by the writer.

In the proposed seventh edition of Standard Methods the "com-

plete" demonstration of coli-aerogenes group on water ready for use is maintained as it has been in essentials since 1917. There is introduced as an outline of an optional procedure for water in process of purification the following material:

III-10. Brilliant green, lactose, peptone bile

This medium may be used for parallel planting with standard lactose broth for water purification plant control, only. It contains brilliant green in a concentration of 1:75000 and 2 percent of bile.

Dissolve 10 grams of peptone and 10 grams of lactose in not more than 500 ml. of distilled water. Add 200 ml. of fresh ox bile or 20 grams of dehydrated ox bile dissolved in distilled water. No dehydrated ox bile should be used which has a pH of less than 7.0. Make up with distilled water to a total of at least 975 ml. and adjust the reaction to a pH of 7.1–7.4. Add 13.3 ml. of a 0.1 percent solution of brilliant green (certified dye) in water and make up to a total of 1000 ml. and filter through cotton. Distribute in tubes and inverted vials and sterilize as directed under sterilization.

When 10 ml. or more of water are to be planted, the concentration of ingredients should be increased as indicated in the following table:

AMOUNT OF WATER SAMPLE	CONCENTRATION OF INGREDIENTS PER 1000 ML. OF MEDIUM	AMOUNT OF MEDIUM PER TUBE
1 ml. or less	10 g. peptone 10 g. lactose 200 ml. ox bile 0.1 per cent brilliant green solution, 13.3 ml.	10 ml.
10 ml. or 100 ml.	20 g. peptone 20 g. lactose 400 ml. ox bile 0.1 per cent brilliant green solution, 26.6 ml.	10 ml. or 100 ml.
10 ml.	15 g. peptone 15 g. lactose 300 ml. ox bile 0.1 per cent brilliant green solution, 20 ml.	20 ml.
10 ml.	13.3 g. peptone 13.3 g. lactose 266.6 ml. ox bile 0.1 per cent brilliant green solution, 17.7 ml.	30 ml.

The medium may be used in the dehydrated form in the following concentrations:

AMOUNT OF WATER SAMPLE	AMOUNT OF DEHYDRATED MEDIUM PER 1000 ML. OF DISTILLED WATER	AMOUNT OF MEDIUM PER TUBE
1 ml. or less	40 g.	10 ml.
10 ml. or 100 ml.	80 g.	10 ml. or 100 ml.
10 ml.	60 g.	20 ml.
10 ml.	53 g.	30 ml.

IX-1

For water purification plant control work, only, it is permissable to use parallel planting in standard lactose broth and brilliant green lactose peptone bile, and to interpret the results without further confirmation.

XI-1. Procedure for routine tests of unfinished waters

(*a*) Arrange in rack or container as many fermentation tube pairs (one lactose broth and one brilliant green bile) as are needed to plant the desired quantity of samples.

(*b*) Inoculate each tube with stated quantity of samples.

(*c*) Incubate at 37°C. Observe gas formation at end of 24 and/or 48 hours as in Standard procedure.

(*d*) If at any time within 48 hours gas is observed in the lactose bouillon tube of any pair, remove therefrom a loopful of the growth and inoculate a tube of Brilliant Green Bile.

(*e*) If at any time within 48 hours 10 percent or more of gas is produced in the lactose broth tube, but at the end of 48 hours no gas is formed in the brilliant green bile tube, a loopful of the growth in the lactose broth tube shall be transplanted to a fresh tube of brilliant green bile. This tube shall be incubated at 37°C. not longer than 48 hours. If at any time during the incubation period, more than 10 percent of gas is produced, the pair shall be recorded as positive for coli-aerogenes group. No further work is necessary.

(*f*) If no gas is formed in either tube of a pair in 48 hours or if gas is formed only in the original lactose broth tube and not upon secondary planting in a brilliant green bile tube, record the pair as negative for coli-aerogenes group.

(*g*) While no further subcultural work is necessary in (*d*) and (*e*) above, if desired, confirmation of B. coli may be made, preferably from the brilliant green bile tube.

(*h*) The present status of the above procedure does not permit its use for evaluation of the quality of the finished water supplies or of those which are used raw without treatment.

The parallel planting procedure as outlined involves the use of two liquid media whose selectivity or inhibiting ability differs. One, lactose broth, is presumed to have no tendency to restrain the activi-

ties of the coli-aerogenes group. Their metabolic activity, evidenced by gas production, is unrestrained. The other, brilliant green bile broth, is presumed to have a definite inhibitive effect upon Gram-positive organisms (the coli-aerogenes group are Gram-negative) and by the presence of bile to favor bacteria that may inhabit the intestinal tract. The former has been criticised as being too catholic in its entertainment of bacterial growth and the latter has been criticised for inhibiting some of the very organisms it is supposed to favor. The parallel planting procedure combines both media in a common task. More than twenty years ago, it was shown that the transplanting of a culture from a sugar broth tube in which no fermentation had occurred might result in fermentation in a second tube of the same material. Ritter (36) in 1918 saw a diagnostic value in planting water samples in both lactose bile and lactose broth. The present procedure seizes upon the value of such routine and permits brilliant green lactose bile to give its prompt indication of massive pollution and at the same time permits lactose broth to rejuvenate organisms whose metabolic activity is slight. But it requires of the latter that—after rejuvenation—they grow and produce gas in the selective broth before the presence of coli-aerogenes group organisms is presumed to be demonstrated.

What has been gained? Time and specificity. Time has been gained in that under the most adverse conditions not more than four days is required to demonstrate coli-aerogenes group by parallel planting procedure. Standard procedure under the same conditions requires seven days for completion. Specificity is gained in that, within twenty-four hours, if both lactose and brilliant green bile broth tubes ferment, the technician has very definite information as to the presence of coli-aerogenes group organisms whose metabolic activity is of the type associated with fresh pollution. In the face of aggressive expression of contrary viewpoint the writer joins the group who hold that delayed gas production in lactose and brilliant green bile broth is less significant. In the case of the all-too common forty-eight hours fermentation of lactose broth, where the brilliant green broth, originally inoculated, does not ferment, a negative result by reinoculation from lactose into brilliant green is obtained within four days after the original inoculation instead of the seven days required by Standard Methods.

There remains a question as to mathematics. What coli-aerogenes density is shown by the parallel planting procedure? It appears

advisable to consider each pair of tubes as a unit-inoculation of the amount planted in one tube. Thus, if pairs are being inoculated with 10 ml. of sample and ten tubes or five pairs are thus planted, five unit quantities or portions are to be considered as having been handled. This is necessary because the technique relates not the handling of single tubes, but to pairs of tubes whose community of action is necessary to the finding.

The above discussion, in a somewhat more extended form, was sent to a group of people over the country for their study and criticism. There was received shortly thereafter a discussion of the subject by Dr. W. H. Frost, in which objection was raised to the suggestion in the closing paragraph concerning coli density computations.

His discussion was referred by the writer to Mr. M. H. McCrady and by Mr. Wolman to Prof. L. J. Reed. An abridged summary of their comments follows.

DISCUSSION

W. H. FROST:[3] Concerning the merit of brilliant green lactose bile as a preliminary test medium, I was and am quite open to conviction; but I objected to several features of the proposals, especially to (1) the attempt to classify the coli-aerogenes group according to results of this test, and (2) the quantitative interpretation, treating a pair of samples as a single unit of the volume contained in each member of the pair.

The proposal which is now put forward in your memorandum (page 4) seems to me a distinct improvement, in that it omits the classification of coli-aerogenes into four groups as originally suggested, thus eliminating one feature to which I had objected. I note, however, that you still propose, on page 7 of your memorandum, to "consider each pair of tubes as a unit-inoculation of the amount planted in one tube." If this means what I take it to mean, application of the rule as stated must inevitably lead to erroneous quantitative interpretations.

The proposed procedure is such that an organism which will produce gas in brilliant green bile (B. G. B.) presumably will be identified if it occurs, on preliminary test, either in the B. G. B. tube or in the lactose bouillon (L. B. tube), the identification in the latter case being made by transfer. Therefore, for any pair of tubes, the test

[3] Professor of Epidemiology, School of Hygiene and Public Health, Johns Hopkins University, Baltimore, Md.

is positive if an organism fermenting B. G. B. is demonstrated in *either or both tubes of the pair.*

Let us take the simplest case, where the only gas-forming organism present in the water is one which will produce gas in brilliant green bile; and let us suppose that wherever we have one or more of these organisms in a test volume we will have a positive test. The number of positive tests, then, should be the same whether the preliminary medium is brilliant green bile or lactose bouillon, positive tests in the latter medium being regularly confirmed by transfer.

Let the density of these organisms in the water under examination be such that the proportion (p) of samples of volume (m) contain one or more of the organisms. Then in a pair of tubes, each containing volume (m) of water, we have possible results of respective probabilities as follows:

	TUBE 1, L. B.	TUBE 2, B. G. B.	PROBABILITY OF OCCURRENCE
Organism	Present	Present	p^2
	Present	Absent	pq
	Absent	Present	pq
	Absent	Absent	q^2

From the above, the probability that one or both tubes of a pair will contain one or more of the organisms is $p^2 + 2pq$, or $1 - q^2$.

As a concrete example, take $p = 0.1$, whence $q = 0.9$. Then, in 100 tests, each of a single volume (m) we should have $p \times 100 = 10$ positive results; that is, 10 percent of samples of volume (m) would show presence of the organism.

In testing 100 *pairs*, each consisting of *two* units of volume (m), the frequency of a positive result in *one or both* tubes of the pair would be $(p^2 + 2pq) \times 100 = 19$. Applying your rule, that a pair should be considered as a single unit of the volume contained in each member of the pair, the interpretation given would be that 19 percent of samples of volume (m) contained this organism. Actually, however, only 10 percent of the samples of this volume would contain the organism, so that the interpretation according to the rule which you have stated would be in error by 90 percent. Taking other values for (p), the proportionate error would vary, but for every value of (p) the interpretation according to your rule, as I understand it, would be erroneous.

If the two equal volumes constituting a pair are to be considered

as a single unit of a given volume, this volume should be twice that which is contained in each member of the pair. Thus, in the example given above, the interpretation according to this rule would be that 19 percent of volumes of 2 (m) contained this organism, whence it could be deduced that 10 percent of samples of volume (m) would contain it.

I have taken only the simplest case, where the water contains only one kind of organism, which is equally certain, when present, to give a positive test in either B. G. B. or L. B. The interpretation of parallel tests becomes much more complicated if several kinds of organisms are present, e.g.:

(1) those which, on primary test, will give gas in either B. G. B. or L. B;

(2) those which on *primary* test will give gas in L. B., and on *transfer* will give gas in B. G. B., but which will *not* show in the latter medium on primary inoculation;

(3) those which will give gas in L. B. but none in B. G. B., even on transfer.

To determine the respective frequencies of these three kinds of organisms in a series of samples would require that *every* positive test in L. B. be checked by a transfer to B. G. B. But when this had been done, it would still be fallacious to consider the combined volumes in two members of a pair as equal to the volume in each single member.

I hope that if and when a revised procedure is adopted it may be as sound as possible; and I am confident that with a little care it is quite possible to outline a parallel planting procedure that will be free from the present objections.[4]

H. E. JORDAN:[1] This analysis of the matter appears to be correct. The opposite viewpoint now appears to have been the result of a subconscious tendency to regard the lactose broth tube as the *dominant* factor in the picture. In other words, so great had grown the desire to avoid the appearance of using brilliant green bile as a sole primary medium that the fact that it received an inoculation of a unit quantity of water and was entitled to mathematical considera-

[4] This opinion was obviously incorrect, since it is evident from Dr. Reed's discussion that if the two media used actually are differential, any parallel planting procedure is illogical.—W. H. F. (May, 1932).

tion was subordinated to the idea that it supplemented rather than paralleled the lactose broth result.

In order to clarify the picture, the five possible results obtainable by the parallel planting method are tabulated and an analysis of each type result follows:

TYPE OF RESULT	PRIMARY TUBE, L. B.	PRIMARY TUBE, B. G. B.	SECONDARY TUBE, B. G. B.	RECORD COLI-AEROGENES IN EACH PORTION EXAMINED
A	+	+	Not required	++
B	+	−	+	++
C	−	+	Not required	−+
D	+	−	−	−−
E	−	−	Not required	−−

It is necessary, at this point, to put at rest a question raised by several persons—can tubes be paired after incubation? No. Pairs must be considered joined as planted. A study of the mathematical effect of random combination of the results in the above table will easily convince a person that post incubation combination of results will decrease the number of coli findings.

Type A result of fermentation indicates that coli-aerogenes organisms were present in both portions of water planted. Many workers may not agree with this statement and suggest that no L. B. fermentation can be taken as actually indicative of coli-aerogenes group presence. The result of this would be to add to the procedure the confirmation of every L. B. fermentation by transplant into B. G. B. It is not desirable thus to add to the details of the procedure. Within the limits of accuracy of the procedure it seems proper to assume that organisms of similar characteristics have been distributed in both tubes and that if chance distribution had placed the sample which went into the L. B. in the B. G. B., fermentation would have occurred.

Type B result differs from A not in the mathematics of the problem, but in the type of organisms present. Again assuming distribution of organisms of similar character in each tube of the pair, we conclude that the coli-aerogenes present are not of the kind that are able initially to ferment in B. G. B. but must have their metabolic activity stepped up by the preliminary enrichment in L. B. Both portions are finally recorded as coli-aerogenes plus.

Type C result should be interpreted as a case in which the distribu-

tion of coli-aerogenes is so sparse that none were planted in the L. B. It has been suggested that fermentation in either tube, if confirmed in B. G. B. should be recorded as positive for both portions. That idea applied to Type C result would require a transplant from a negative L. B. tube to B. G. B. if the primary B. G. B. tube had fermented. Here again it appears undesirable to complicate the procedure by adding operations. The question is rather a moot one and it probably is preferable to suggest at the moment that the study in detail of ±100 cases of type C result is required before an interpretation opposite to the procedure indicated can be supported. We here tend to involve ourselves in a broader question than that of the parallel planting procedure, namely, how often does L. B. fail to indicate the presence of true coli-aerogenes. A re-examination of 1000 tubes originally planted in L. B. according to standard procedure where no gas was produced during the regular incubation period would show not zero, but x times in which the organism was originally present. It appears wiser from the broader aspect of actual sanitary values in laboratory work to allow this x group to remain lost than to complicate routine by an over meticulous effort to find them.

Type D result brings into play the diagnostic value of the B. G. B. Original gas production in L. B. is shown to be the result of the activity or organisms that cannot—even after rejuvenation—produce a similar result in B. G. B. coli-aerogenes according to the reasoning underlying the entire procedure, are absent in both portions examined.

Type E result is negative in both portions.

The difference between the two methods of mathematical interpretation now may be analyzed. Assume that 100 ml. of water have been planted—10 ml. in each of 5 tubes of L. B. and 10 ml. in each of 5 tubes of B. G. B. As originally outlined the result in the 5 cases above shown would have been tabulated as coli-aerogenes present in 3 of 5 to 10 ml. portions. But considering each tube of a pair as representing 10 cc. of water, after all work had been done, coli-aerogenes would be recorded as present in 5 of 10 to 10 ml. portions.

A more important aspect of the matter is this, that by considering the pair of tubes as containing only the quantity planted into one, the severity of the test was increased. Following the proposed routine would have led the laboratory worker to examine 20 ml. of water for each 10 ml. recorded. This in effect would have very materially increased the severity of test applied to the sample. In

the case of unfinished waters, the result would have been to increase the apparent efficiency of the step in the process that intervened between the last sample studied by the parallel planting method and the finished water examined according to standard procedure. If the procedure happened to be applied to a water ready for use the result might be to produce an adverse verdict as to its conformance to the Treasury Standard because of the under assumption as to the quantity of water being studied. While a desire to safeguard the water consumer by adequate laboratory study with reasonable technique is desirable, it is not necessary to produce this safety by so material an increase in the severity of the test as the criticism has shown the first method of density computation to produce.

The material up to this point was made available to Mr. McCrady and Dr. Reed. Their discussion follows.

M. H. McCrady:[5] At the outset, I would state that, if possible, we should have the same method for finished as well as unfinished waters. I agree, also, that a clear definition of the coli-aerogenes group is necessary; we must have something to "shoot at." Further, I should like to see the present method retained as a reliable method for use in those cases where definite, conclusive results, derived from a more strictly scientific procedure, are demanded for particular reasons. This method, in other words, might serve as a last resort in special or research work.

But because of the time, effort and cost involved in this confirmation procedure, I should prefer an alternative method for ordinary routine work. I believe much more would be gained than lost by the adoption of an alternative procedure, provided it is fairly reliable and comparatively simple.

For the purpose of discussion we may compare the standard method with the system of planting in lactose broth and confirming with secondary B. G. as representing the simplest variant of the B. G. method. I think the following is a fair comparison:

1. The B. G. method should prove much less costly than the present method in time, in materials and in apparatus.

2. The labor involved in the present procedure induces a tendency to limit the number of samples examined and to limit the amount of work done on the single sample. Many laboratories employ

[5] Provincial Board of Health, Montreal, Quebec, Can.

only one tube at each dilution for control work. I have always maintained that the results obtained from this system convey little reliable information regarding the quality of the single sample. Yet I believe we should know more about this single sample—the monthly average of results may be of interest, but the results from the single sample determine our judgment of the degree of purification effected or of the safety of the final water at the time of sampling. Some recognition of this argument is indicated in the recommendation (but not requirement) of the use of 5 tubes by the present standard method.

The simplicity of the alternative B. G. method of confirmation would permit specification of a minimum of 5 tubes with 10 cc. and 5 tubes with 1 cc., with the reasonable expectation that this requirement would be accepted. Such a system should give a reasonably precise indication of the coli content of the single sample.

3. The present method leaves much to the personal preferment of the worker; choice of planting media, planting technique, fishing technique, purification of cultures, method of Gram staining and method of microscopical examination.

This personal preferment is evidenced again by the frequent compromises effected between the amount of work which the laboratory can handle and the requirements of the standard method, with the result that a variety of systems and procedures are employed.

The use of the alternative B. G. method should eliminate entirely this personal factor and results should be strictly comparable.

4. The standard method requires confirmation of the smallest portion showing presence of gas. With results of the type 3/5 in 10 cc., and 1/1 in 1 cc. and failure of confirmation of the 1 cc. tube, a difficulty in interpretation arises.

With B. G. method, confirmation of every positive L. B. tube could be required, with entire elimination of difficulties such as that described.

In all the above, I am assuming that we accept confirmation by B. G. as sufficiently indicative, for practical purposes, of the presence of organisms conforming to our definition. To me, this is the main question: has the experience with this B. G. confirmation been such as to justify our acceptance of it, for practical, routine purposes, as an indication of the presence of our defined organism? If so, I can see no objection to offering it as an alternative.

I doubt that we are claiming, in this event, a new characteristic

for our defined organism. Rather, we are specifying concentrations of brilliant green and bile which we consider do not, as a rule, inhibit our defined organism, but which do inhibit many interfering organisms. Similarly, we specify concentrations of eosin and methylene blue for our E. M. B. plate which will not inhibit coli. I do not think of growth *per se* on this plate as a new characteristic of the coli group. Yet one of the important advantages of this medium is that it inhibits the growth of some organisms but does not seriously inhibit our defined coli. In consequence, the acceptance of the B. G. confirmation procedure would not, in my opinion, involve any radical departure from our present definition.

After all, the main consideration is whether the adoption of such an alternative will endanger the public health. I can hardly believe that the organisms which might be inhibited by B. G. are of greater importance than the organisms conforming to our definition which we miss by our present choice of media and short incubation periods. If the quality of a sample is questionable, I believe the B. G. procedure will reveal that fact.

On the other hand, if the plant operator consider his B. G. positives to be excessively numerous he would always have the alternative of the present procedure.

I have taken the system of L. B. primary with B. G. secondary confirmation as an example for comparison. The parallel planting procedure would serve equally well for this purpose, except in the matter of general applicability, for I fear that the errors involved in the interpretation of results obtained from the parallel procedure may not be countenanced by some workers, even when the procedure is applied to unfinished waters. I am thinking particularly of prechlorinated waters where the proportion of organisms fermenting only L. B. primary may be of some magnitude.

I feel that some alternative of the present standard method is demanded by many water laboratory men. If I am not mistaken, New York, Washington, Chicago, Toronto, to mention only a few cities, all are using methods which are different and which are not strictly identical with the standard method. This practice would indicate a practical need for a simplified procedure and I think a real effort should be made to agree upon some such alternative for inclusion in the next edition of Standard Methods.

My one dominant thought back of all this is that more intensive sampling and more complete investigation of the single sample are

desirable. Where the safety of large populations is dependent upon laboratory results, I feel that sampling can hardly be practised too frequently and that the result obtained from the single sample should be sufficiently precise to permit detection of marked abnormality in the quality of that sample. The danger attendant upon infrequent sampling and cursory examination of the single sample far outweighs, in my opinion, any danger involved in the selective operation of the procedures we are discussing. But if we are to have frequent sampling together with fairly precise results, a simplified alternative procedure is necessary. Hence my attitude toward the use of the B. G. medium.

When it comes to the interpretation of parallel planting, however, as suggested by Mr. Jordan, a number of errors are to be expected. Thus, taking an example where the sample contains about 10 coli per 100 cc. which can ferment both primary media, and 1 cc. of the sample is planted in each of 100 tubes of each medium, we may expect 10 positives in each medium distributed, on the average, as follows:

1 pair with both media fermented.
9 pairs with B. G. fermented and L. B. not fermented.
9 pairs with L. B. fermented and B. G. not fermented.
or 19 pairs with either both tubes or one tube positive.

The result is read as 19/100 with 2 cc. (2 *m* is the unit) or roughly, 10/100 with 1 cc., which means the 10 coli per 100 cc. with which we started.

Mathematically, the short cut from 19/100 with 2 cc. to 10/100 with 1 cc. is not permissible. When the proportion of positives is high a considerable error is introduced by this method. This was one reason for my suggestion of planting only half the usual portions of sample (previous communication).

But now consider the case where the same number of coli can ferment only the L. B. primary (and B. G. secondary). Here we shall have no positives in the B. G. primary medium, but 10 positives in the L. B. primary. Proceeding as before, the result is read as 10/100 with 2 cc., or roughly, 5/100 with 1 cc., which means 5 coli per 100 cc. or only half the number of coli with which we started.

In consequence we shall always have this error of 50 percent in the proportion of positives due to organisms which ferment L. B. but not B. G. primary.

If, on the other hand, we assume that all the organisms present are of the type (*b*) which ferment only L. B., the assumption involved, by the way, in your first method of interpretation on the basis of the volume (*m*), the error involved in the estimate of type (*a*) organisms which ferment both media is a variable error depending upon the number of type (*a*) organisms present.

It may be shown that when only type (*a*) organisms are present the error resulting from this assumption is equal to the expected proportion of negatives. Thus, if the sample contains 1 coli per 100 cc. the expected proportion of positive 10 cc. portions is 1/10 and the expected proportion of negatives is 9/10. In this case the error is 9/10 or 0.90 or 90 percent, and in the average of results over a period of time, this will be the error. In the example of Dr. Frost, given above, where we had this same case with 19 positive pairs, had we read the results as 19/100 with 1 cc. our error would have been 90 percent.

It is to be noted that the error with either assumption may not appear of great significance in the result from a single sample, but when averages of many results are computed, the error is sure to affect such averages.

Of the two assumptions indicated, the first appeared to me preferable since I assumed that the majority of coli in unfinished waters would ferment both primary media. But in those cases where the assumption generally fails, and where an error of 50 percent is considered important, the method could not be advised.

Even though all L. B. primary positives are confirmed with secondary B. G. I do not find any practical method of avoiding these assumptions. It is true that a general formula may be derived to give the true proportion of positives which should be obtained, regardless of the type of organism present, but any such formula which I have been able to find is of value only when a large number of pairs are used with similar samples. One such formula is the proportion given by dividing the number of pairs of the type B. G. − L. B. + by the total of B. G. negatives. Thus, in the example we had 9 pairs with the result B. G. − L. B. + and 90 B. G. negatives. The proportion is 9/90 or 1/10 positive, which is the expected proportion when working with 1 cc. portions of sample. I believe this formula to hold rigidly, even for mixtures of organisms of the two types, but it is impossible to apply this formula to the limited series of results from one sample. Thus with the very probable result

B. G. +++−−
L. B. ++−−−

this formula would give 0/2, which is meaningless.

In my opinion, it is impossible to interpret the results obtained from the parallel planting procedure without adopting one or the other of these assumptions.

If the errors entailed by these assumptions are inadmissible, I see no alternative to the system of planting lactose broth alone, confirming with secondary B. G. and interpreting the results in the usual manner. Of course, in such event, we lose the advantage of the early indications given by the B. G. primary. But the little labor involved in this method of confirmation of L. B. positives, as compared with the present arduous procedure of Standard Methods, might justify the recommendation that B. G. or similar media be used along with the L. B. to give earlier warning of unsatisfactory conditions, even though the results obtained by means of such media be not included in the official record (which would include only the results from the L. B. with secondary B. G. confirmation).

Two features of the experience encountered in the use of B. G. are of importance, viz.,

a. That B. G. proved to be a very satisfactory presumptive media for many waters.

b. That confirmation of L. B. primary with secondary B. G. constituted a satisfactory procedure with practically all waters to which it was applied.

The first indicates B. G. as a favorable medium for obtaining fairly reliable *early* results; the second indicates B. G. as a possible way out of the difficulties of application of the present involved confirmation procedure to routine work. It seems that it should be possible to employ these advantages of B. G. in some system which would serve as an alternative to the present Standard Method for routine examination of unfinished, or better, of all waters.

The possible methods of precedure that we have considered may be summarized as follows:

1. Employ parallel planting of 10 cc. portions of sample, interpret on the basis of 20 cc. and accept the error of 50 percent in the estimate of organisms which ferment only L. B. primary and B. G. secondary. In this case a special calculation is necessary to reduce 20 cc. results to 10 cc. results when the proportion of positives is high.

2. Employ parallel planting of 10 cc. portions, interpret on the

basis of 10 cc. and accept an error varying from 100 percent (when positives are few) to about 10 percent (when positives are numerous) in the estimate of organisms which ferment both primary media.

3. Employ parallel planting of 5 cc. portions and interpret as in (1) or (2). In the interpretation according to (1) the results are obtained on the basis of 10 cc. and no special calculation is required.

The same errors as those noted in (1) and (2) must be accepted when planting 5 cc. portions.

4. Employ single planting of 10 cc. portions of sample in L. B. and confirmation of all L. B. positives with secondary B. G., with or without recommendation to employ additional B. G. presumptives for unofficial testing.

In this case no difficulties in interpretation should be encountered.

LOWELL J. REED:[6] The discussions of the interpretation of the results of the parallel planting procedure, as given by Dr. Frost and Mr. McCrady, seem to bring out most of the difficulties involved. It might be well, however, to summarize certain of the fundamental assumptions that are involved in the mathematical processes back of the interpretation of tube results in terms of density of organisms. The dilution tube test and its density interpretation has its foundation in that portion of the probability theory which deals with samples that have been made small enough so that we have created a reasonably large probability that the event which we are trying to observe will not occur. It is the actual occurrence of negative results brought about by using a dilution scale that enables us to make an interpretation in terms of density of organisms. In addition to this, the probability theory under which we are operating proceeds as though the effect produced (that is, gas formation) would always be produced by a certain minimum amount of the substance measured (that is, the organisms). When we state our results in terms of density of organisms, this implies an assumption that the presence of one organism in a dilution tube would produce gas. Consideration of the fact that we are dealing with a group of organisms that certainly vary as to species and as to minor characteristics would lead us to believe that instead of a basic minimum unit of one organism producing the end result, we may well have some basic statistical unit which is an average of organisms as to species and number. When we state

[6] Professor of Biostatistics, School of Hygiene and Public Health, Johns Hopkins University, Baltimore, Md.

density, therefore, we are probably stating not number of individual organisms per cubic centimeter, but number of this basic statistical unit per cubic centimeter. These facts are not new in the problem of interpretation of fermentation tube results, but it is well to review them if we are going to combine two methods of testing as given in the procedure on parallel planting.

The planting procedure outlined really involves two tests, one a planting in primary B. G. B. tubes and the other a primary planting in an L. B. tube, with a secondary transfer to B. G. B. This planting in L. B. is really a growth process of a certain type of organism and a transfer to a secondary tube of an amount that can not be stated in any scale of dilution, and it would therefore seem impossible to put these two tests together by any procedure unless the minimum unit or organisms that would produce gas in B. G. B. is the same as the minimum unit of organisms that would grow in the primary tube in L. B., and then produce gas on transfer to B. G. B. That would amount to an assumption that the two tests were identical, and would therefore do away with the necessity of parallel planting. Our observations show that these two tests do differ in character and therefore the above assumption must be unsound, and yet it is a necessary assumption if we are to interpret our tubes in combination in any of the forms suggested. We can illustrate this specifically by turning to the case outlined as follows:

"

TYPE OF RESULT	PRIMARY TUBE, L. B.	PRIMARY TUBE, B. G. B.	SECONDARY TUBE, B. G. B.	RECORD COLI IN EACH PORTION EXAMINED
A	+	+	Not required	++
B	+	−	+	++
C	−	+	Not required	−+
D	+	−	−	−−
E	−	−	Not required	−−

Considering this to be the result obtained from 5 pairs of tubes with 10 cc. of sample planted in each tube, the result should be interpreted as $\frac{3}{5}$ in 20 cc., since in three of the five cases B. G. has given positive results."

If we are to call 10 cc. positive when we have gas formed in our secondary B. G. B. tube after a previous incubation in L. B., we would certainly classify results A, B, and C as samples of 20 cc. that give positive results, but when we come to results D and E we would be uncertain as to whether they were positive or negative for the 20 cc. since we could not be sure that the particular 10 cc. planted in

the primary B. G. B. tube would not have been positive after planting in a primary L. B. tube and then transferred to B. G. B. The reasons for this are of course exactly the reasons given by Mr. McCrady in his argument against considering the samples as of 10 cc. in size. The very fact that our dilution method reduces us to this probability balance point is the reason for our uncertainty as to whether this sample of 20 cc. is positive. The summarizing of the results of these two methods into a single statement of the end result by any process whatsoever must involve some statement of the equivalence of one test in terms of the other and if such a statement can be made, it obviously destroys the necessity for making both tests. Thus, it would seem to me impossible to hope to get any explanation of a combined result that did not carry with it an implicit assumption that logically destroyed the parallel planting procedure. It is of course obvious that they might be used as tests defining different groups of organisms and they could be used independently to create an index of the prevalence of the organisms of these two differently defined types.

HARRY E. JORDAN:[1] It is evident, from the discussion by Messrs. Frost, McCrady and Reed, that the writer's suggestion as to mathematical interpretation of results from parallel planted tubes, does not stand critical analysis. It is therefore proper to accept the suggestion of Mr. McCrady that the technique of subculturing into a brilliant green bile tube from a lactose bouillon tube, in which gas is found, be adopted. Reference to earlier work (7) (20) indicates that this procedure has been tried and found to be quite specific for organisms of the Bact. coli group, much more so than the present "Confirmed" technique which involves a transplant from lactose bouillon to endo or E. M. B. agar. The writer suggested its utility in 1925 (7) and later dismissed it for what appeared to him to be the superior diagnostic value of the parallel planting procedure.

It is possible to take advantage of whatever value either medium has by using primary lactose bouillon and secondary brilliant green bile fermentation as the evidence upon which the presence and density of the Bact. coli group is computed. Generally, such procedure will give a slightly lower density picture than the present "complete" technique, but require not less than 48 hours nor more than 96 hours to finish, while the "Complete" test requires not less than 96 hours to finish. At the same time, if the technician desires, he may plant

in parallel both lactose bouillon and brilliant green bile, normally using the results from the former for such density interpretations as he may wish and the latter for its specificity and diagnostic value. It requires little experience in the use of the parallel planting method for the operator to sense clearly changes in the performance of the various steps in purification processes by the distance through the plant at which positive results in primary B. G. B. tubes are found or their frequency varies.

For example, if, after sedimentation and filtration, but prior to final chlorination, it is not normally the experience to find gas produced in B. G. B. tubes, but on a certain day one or more tubes are positive, the operator should clearly recognize that an increased load has been put upon final chlorination and doubtless would take steps to correct the condition. In all probability, the ordinary lactose bouillon tube will show a reasonable frequency of gas positives at this print and no change will occur in the quality picture that it presents until the secondary B. G. B. tubes are found to be positive. It is clearly seen that a twenty-four-hour gain is made by the use of the parallel planting and the writer is not greatly concerned at discarding the mathematical interpretation from parallel planting if the operator is permitted to use it for such diagnostic value as it has.

Accordingly it is suggested that the text in section XI-1 be modified to read as follows:

(*a*) Arrange in rack or container as many fermentation tube pairs (one lactose bouillon and one brilliant green bile) as are needed to plant the desired quantity of samples.

(*b*) Inoculate each tube with stated quantity of sample. These may be referred to as the primary tubes.

(*c*) Incubate at 37°C. Observe gas formation and end of 24 and/or 48 hours as in standard procedure.

(*d*) If at any time within 48 hours more than 10 percent gas is observed in the lactose bouillon tube of any pair, remove therefrom a loopful of the growth and inoculate a tube of brllliant green bile. These tubes may be referred to as the secondary tubes. Incubate the latter at 37°C. and discard the primary lactose bouillon tube.

(*e*) Observe gas formation in the secondary brilliant green bile tube at the end of 24 and/or 48 hours.

(*f*) If at any time within 48 hours, more than 10 percent gas is observed in the brilliant green bile secondary tube, record as positive for coli-aerogenes group the corresponding primary lactose bouillon tube.

(*g*) Any computations as to density of bacteria coli-aerogenes group resulting from gas observed in secondary brilliant green bile tubes

shall be referred to the quantity planted in the primary lactose bouillon tube.

(*h*) If at any time with 48 hours 10 percent or more gas is produced in the primary brilliant green bile tube of any pair, it shall be recorded as positive, and may be taken as evidence of the presence of active strains of organisms of the bacteria coli-aerogenes group and may be interpreted by the operator according to his previous experience in the control of the plant or plants in his charge.

It may be that the advantages of the parallel planting of primary brilliant green bile tubes may not be apparent to those laboratory workers who have not yet used it. It is hoped that they will not deny themselves its diagnostic value. If, however, it is felt that the demands upon some laboratories are such that the parallel plantings cannot be made, it is feasible to use the lactose bouillon primary and brilliant green secondary planting for confirmation of the coli-aerogenes group in waters in process of purification.

It may be further suggested that a great deal of valuable statistical data can be accumulated by workers who take the time to complete the determination of the coli-aerogenes group from the same primary lactose bouillon tube that is used to inoculate the secondary brilliant green bile tube. There will be thus developed figures showing just what difference in data, if any, results from use of the new method.

CONCLUSION

Messrs. Frost, McCrady, Reed, Norton and Wolman have done a service to the water laboratory field by their constructive criticism of the material as originally presented. The original text and successive discussions, somewhat condensed, are presented with their cross currents of thought, in order to record the subject reasonably fully with the hope that workers in the field will profit thereby.

In conclusion the writer ventures the assertion, that when water works and public health laboratories have had a reasonable length of experience with the suggested procedure, it will be clear that no lessening has been made in requirements for good quality in water and a material gain has been made in the speed of obtaining reasonably accurate information. After all, the major function of an operating laboratory—protecting the public—rests in a reasonable blending of promptness and accuracy. This, it is believed, is achieved by the method outlined.

REFERENCES

(1) BRONFENBRENNER, J.: "On Methods of Isolation and Identification of the Members of the Colon Typhoid Group of Bacteria." Journal of Bact., Vol. 5, page 79, 1919.

(2) BUNKER, J. M.: "Value of Lactose Bile for B. Coli Presumptive Tests." Jour. of Bact., Vol. 1, page 85, 1916.

(3) CHURCHMAN, J. W.: "Bacterial Action of Gentian Violet." Jour. of Exper. Med., Vol. 16, page 221, 1912.

(4) CHURCHMAN, J. W.: "Communal Activity of Bacteria." Jour. of Exper. Med., Vol. 33, page 579, 1920.

(5) DOMINICK, J. F., AND LAUTER, C. F.: "Methylene Blue and Brom Cresol Purple in a Differentiating Bacteria of the Colon Group." Jour. of A. W. W. A., Vol. 21, page 1067, 1925.

(6) DUNHAM, H. G., AND SCHOENLEIN, H. W.: "Brilliant Green Bile Media." Stain Tech', Vol. 1, page 129, 1926.

(7) DUNHAM, H. G., MCCRADY, MACH. H., AND JORDAN, H. E.: "Studies of Differential Media for Detection of B. Coli in Water." Jour. of A. W. W. A., Vol. 14, page 535, 1925.

(8) FROST, W. H.: "Confirmatory Test for B. Coli in Routine Water Examination." Amer. Jour. of Pub. Health, Vol. 6, page 585, 1916.

(9) HALE, F. E.: "Recent Suggestions Relative to the Sanitary Examination of Water." Jour. A. P. H. A., Vol. 16, page 428, 1926.

(10) HALE, F. E., AND MELIA, T. W.: "Studies in Inhibition, Attenuation, and Rejuvenation of B. Coli." Jour. of Infec. Dis., Vol. 9, page 587, 1910.

(11) HALE, F. E.: "Discussion of Paper on Brilliant Green Bile Media" (see 6 above). Stain Tech., Vol. 2, page 24, 1927.

(12) HALL, I. C., AND ELLEFSON, L. J.: "The Elimination of Spurious Presumptives Tests for B. Coli in Water by use of Gentian Violet." Jour. of Bact., Vol. 3, page 329, 1917.

(13) HALL, I. C., AND ELLEFSON, L. J.: "Further Studies on Gentian Violet as a Means of Eliminating Spurious Presumptives Tests for B. Coli in Water." Jour. of A. W. W. A., Vol. 6, page 67, 1919.

(14) HALL, I. C.: "Bacteriological Control of Water Supplies." Jour. A. W. W. A., Vol. 19, page 69, 1928.

(15) HOLMAN, W. L., AND MEEKISON, D. M.: "Gas Production by Bacterial Synergism." Jour. of Infect. Dis., Vol. 39, page 156, 1926.

(16) HOWARD, N. J., AND THOMPSON, R. E.: "Isolation of Colon Group in Water." Canadian Eng., page 3, April, 1925.

(17) JACKSON, D. D.: "A New Solution for the Presumptive Test for B. Coli." Biological Studies by the pupils of Wm. T. Sedgwick, page 292, 1906.

(18) JACKSON, D. D., AND MUER, T. C.: "Liver Broth: A Medium for Determination of gas-forming Bacteria in Water." Jour. of Infect. Dis., Vol. 8, page 289, 1911.

(19) JORDAN, E. O.: "Inhibitive Action of Bile on B. Coli." Jour. of Infec. Dis., Vol. 2, page 326, 1913.

(20) JORDAN, H. E.: "Brilliant Green Bile for the Detection of the Colon Aerogenes Group." Jour. of A. W. W. A., Vol. 18, page 337, 1927.

(21) JORDAN, H. E.: "Lactose Broth Fermenters." Jour. of A. W. W. A., Vol. 22, page 544, 1930.
(22) KLIGLER, J. L.: "A Study of the Antiseptic Properties of Certain Organic Compounds." Jour. of Exper. Med., Vol. 27, page 463, 1918.
(23) KRUMWEIDE AND PRATT: "Further Observations on the Growth of Bacteria on Media Containing Various Anilin Dyes, With Special Reference to an Enrichment Method for Typhoid and Paratyphoid Bacilli." Jour. of Exper. Med., Vol. 19, page 501, 1914.
(24) KRUMWEIDE AND PRATT: "The Use of Brilliant Green for Isolation of Typhoid and Paratyphoid Bacilli for Feces." Jour. of Infect. Dis., Vol. 18, page 1, 1916.
(25) LAUTER, C. J.: "Earlier Determination of Bacterium Coli." Water Works, Vol. 65, page 451, 1920.
(26) LEAHY, H. W.: "Comparison of the Dominick-Lauter Presumptive Test and 'Standard Methods' Test for B. Coli in Water." Jour. A. W. W. A., Vol. 22, page 1490, 1930.
(27) LEITCH, G. B.: "Disturbing Factors in the Presumptive Test for B. Coli." Jour. of A. W. W. A., Vol. 13, page 186, 1925.
(28) LEVINE, MAX: "Does Bile Inhibit or Stimulate Growth of the Colon Group?" Jour. of A. W. W. A., Vol. 9, page 612, 1922.
(29) MELIA, T. W.: "An Improvement in the Composition of Lactose Bile." Amer. Jour. of Public Health, Vol. 5, page 1168, 1925.
(30) MUER, I. C., AND HARRIS, R. L.: "Value of Brilliant Green in Eliminating Errors Due to the Anerobes in the Presumptive Test for B. Coli." Jour. of Pub. Health, Vol. 10, page 874, 1920.
(31) NEILSON, N. M., AND MYER, K. E.: "The Bacteriostatic and Germicidal Properties of Bile." Jour. of Infect. Dis., Vol. 28, page 542, 1921.
(32) OBST, M. M.: "Bile Compared with Lactose Bouillon for Determining the Presence of B. Coli in Water." Jour. of Bact., Vol. 1, page 73, 1916.
(33) POE, C. F.: "Growth of Anaerobes in Crystal Violet Bile Media." Jour. of Bact., Vol. 19, page 133, 1929.
(34) POE, C. F., AND WITT, N. F.: "Growth of Anaerobes in Bile Media Containing Malachites Green and Brilliant Green." Jour. of A. W. W. A., Vol. 22, page 1365, 1930,
(35) RAKIETEN, M. L., AND RETTGER, L. F.: "Brilliant Green and Its Use in an Enrichment Medium in the Isolation of Typhoid and Paratyphoid Organisms." Jour. of Infect. Dis., Vol. 41, page 93, 1927.
(36) RITTER, N.: "The Value of Presumptive Test of Bacillus Coli Based on the Routine Use of Lactose Bile and Lactose Broth." Jour. of Bact., Vol. 4, page 609, 1919.
(37) RUCHHOFT, C. C.: "Comparative Studies of 'Standard Methods' and Brilliant Green Bile Medium on Lake Michigan Water at Chicago." Jour. of A. W. W. A., Vol. 16, page 778, 1916.
(38) RUCHHOFT, C. C., KALLAS, J. G., AND CHINN, BEN: "Gas Production and pH Determination of Coli-Aerogenes Cultures in Sugar Broth." Jour. A. W. W. A., Vol. 23, page 565, 1931.

(39) RUCHHOFT, C. C., AND KALLAS, J. G.: "Brilliant Green Bile as a Confirmatory Medium." Privately circulated manuscript.

(40) SEARS, H. J., AND PUTNAM: "Gas Production by Bacteria in Symbiosis." Jour. of Infect. Dis., Vol. 32, page 270, 1927.

(41) STEARN, E. W., AND STEARN, A. E.: "The Chemical Mechanism of Bacterial Behavior." Jour. of Bact., Vol. 9, page 491, 1924.

(42) STEARN, E. W., AND STEARN, A. E.: "A Study of the Chemical Differentiation of Bacteria." Jour. of Bact., Vol. 10, page 13, 1925.

(43) WINSLOW, C.-E. A., AND DOLLOFF, A. F.: "The Relative Effects of Certain Triphenyl Dyes Upon the Growth of Bacilli of the Colon Group in Lactose Broth and Lactose Bile." Jour. of Infect. Dis., Vol. 31, page 302, 1925.

HYDROGEN ION CONCENTRATION IN DISINFECTION BY CHLORINATION

By W. L. Mallmann[1]

No great attention has been paid to the hydrogen ion concentration of the swimming pool or municipal water supply where chemical purification is used. It is true that water purification authorities have advised an alkaline reaction, but this has been done only in the interest of maintaining a proper alkaline reaction for the flocculation of the alum. In too acid a medium, alum goes into solution in the water, and passes through the filters. The result, in a swimming pool, is a lowering of the efficiency of the filter and the production of an opalescent water. The influence of the reaction of the water on the disinfecting action of the chlorine has never been considered. It has been known for many years that chlorine behaves differently in the presence of acids and alkalies. Rideal and Evans (1921) pointed out that hypochlorites should be better oxidizing agents in an acid than in an alkaline solution. Holwerda (1928) demonstrated that 0.02 p.p.m. of chlorine at pH 5.9 was as effective as 0.2 p.p.m. at pH 9.0. The writer has observed on several occasions pollution in a swimming pool when a residual chlorine content of more than 0.2 p.p.m. existed. No satisfactory explanation of such conditions could be found. To determine the significance of reaction in pool disinfection the following experiments were conducted.

EXPERIMENTAL

Similar residual chlorine contents were compared at different hydrogen ion concentrations, using *Escherichia coli* as an index of germicidal activity. Flasks containing a liter of sterile distilled water with a constant residual chlorine content were adjusted to different pH values. A known number of *Escherichia coli* was added to each flask and at intervals of 1, 5, 10, 15, 20, 30, and 60 minutes 1 cc. portions were removed and planted into test tubes containing 4 cc. of nutrient broth. The organic matter in the broth destroyed the residual chlorine present and thus prevented any further germicidal

[1] Michigan State College, Engineering Experiment Station, East Lansing, Mich.

action. Appropriate dilutions of the inoculated broth were made and plated on nutrient agar to determine the number of bacteria surviving each interval of exposure. All cultures were incubated at 37°C and readings were made after 24 hours incubation. A control, containing only sterile distilled water at pH 7, was made in all cases to measure the mortality caused by suspending the organisms in distilled water.

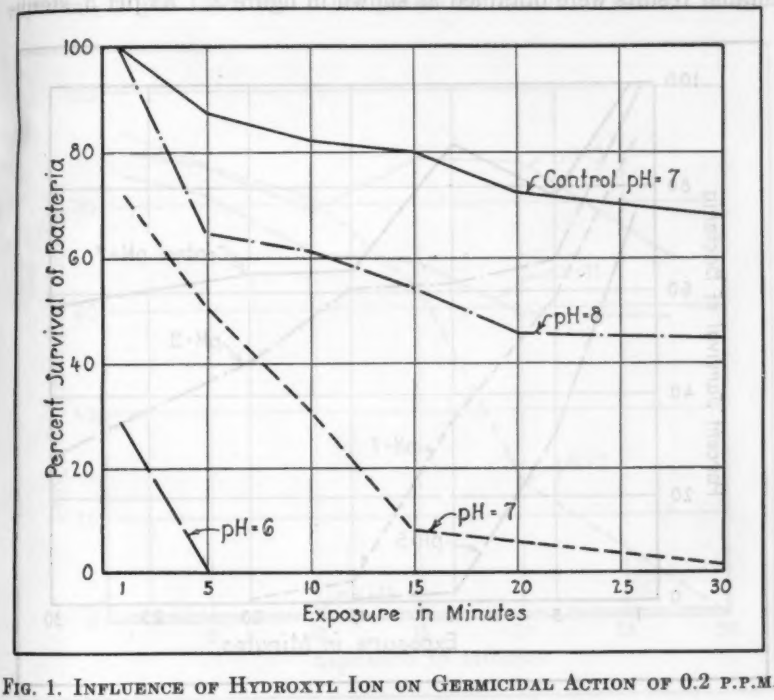


FIG. 1. INFLUENCE OF HYDROXYL ION ON GERMICIDAL ACTION OF 0.2 P.P.M. AVAILABLE CHLORINE ON ESCHERICHIA COLI

In the first experiment, the significance of acid and alkali menstruums was determined. Comparisons were made of pH 6, 7, and 8, using 0.2 p.p.m. available chlorine. The results obtained appear in figure 1. At pH 6 all of the *Esch. coli* were killed in 5 minutes; at pH 7, approximately 1 percent survived 30 minutes' exposure; while at pH 8, 44 percent of the bacteria survived the 30-minute period of exposure. It is thus clearly demonstrated that a shift from an acid to an alkaline reaction caused a marked change in the germicidal action of the chlorine. This confirms the results obtained by Hol-

werda (1928). Not only is the germicidal action lessened, but the rate of destruction is materially affected. A marked decrease in the rate of destruction takes place so that, for a given length of time, the fall in number of surviving bacteria is quite different.

In the second experiment wider ranges in the hydrogen ion concentration on both sides of neutrality were tried. The three pH values selected were 5, 7, and 9 with a residual chlorine content of 0.2 p.p.m. Similar results were obtained as shown in figure 2. At pH 5, sterili-

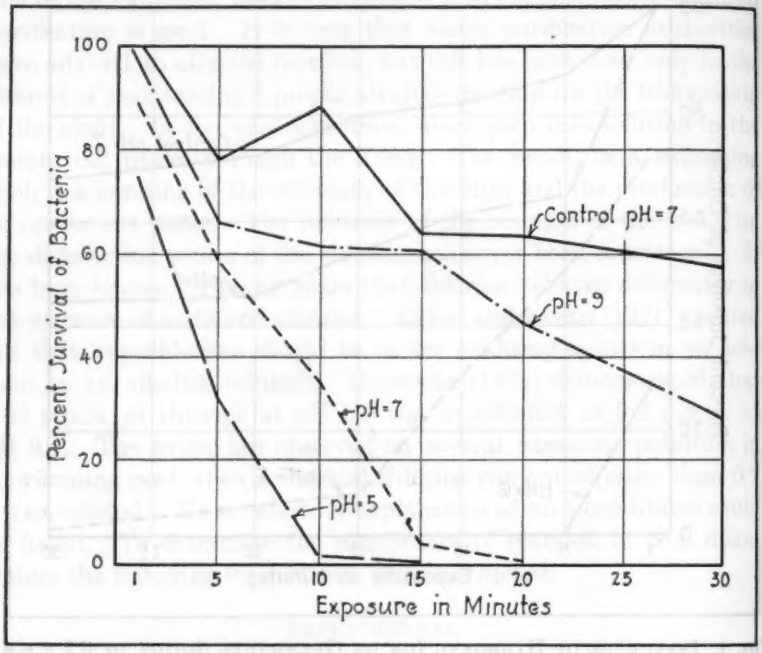


FIG. 2. THE INFLUENCE OF HYDROXYL ION ON GERMICIDAL ACTION OF 0.2 P.P.M. AVAILABLE CHLORINE ON ESCHERICHIA COLI

zation was obtained in 15 minutes, and at pH 7 in 20 minutes, while at pH 9, 38 percent of the bacteria survived 30 minutes' exposure. The results thus confirm the findings of the first experiment.

In the third experiment increasing amounts of alkali were tested to determine the effect of strong alkaline reactions toward the germicidal action of chlorine. The effects of acid on chlorine were ignored in this study because pH values below 6 are not met with in water and sewage disinfection. In this experiment pH values of 7, 9,

11, and 13 were tested using 0.2 p.p.m. available chlorine. *Escherichia coli* was used as a test organism. The results are presented in figures 3 and 4. In figure 3 are presented the survival curves obtained for the action of the alkali alone. In the case of the alkali alone it was found that pH values of 7, 9, and 11 show very little, if any, germicidal action toward *Esch. coli*. In general, however, pH 11 seems to cause a slight decrease in numbers. This was not unexpected, as pH 13 caused a complete destruction of the bacteria in

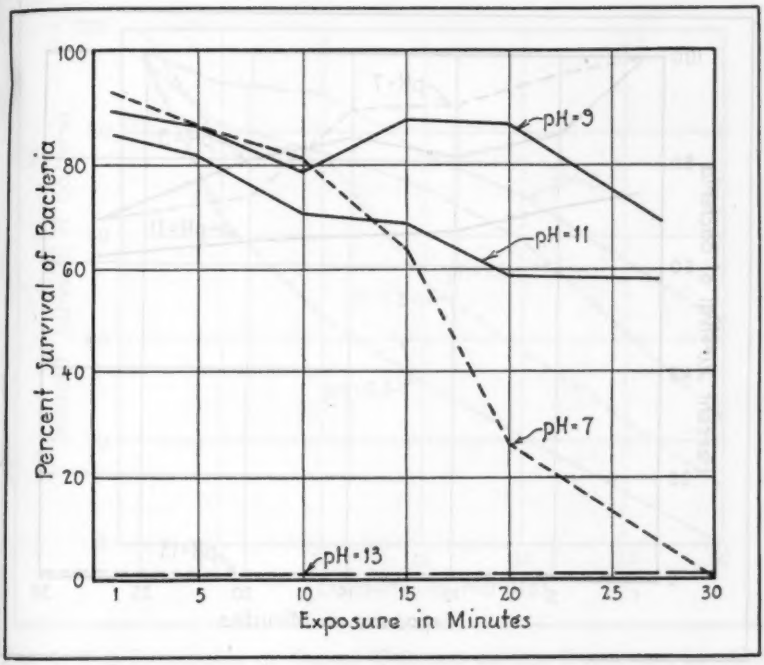


FIG. 3. THE INFLUENCE OF HYDROXYL ION ON GERMICIDAL ACTION OF 0.2 P.P.M. AVAILABLE CHLORINE ON ESCHERICHIA COLI

1 minute exposure. Very likely at pH 11 significant germicidal action of the alkali is beginning to manifest itself. The influence of the 0.2 p.p.m. available chlorine on the germicidal action in this experiment is quite interesting. At pH 7 sterilization was obtained in 30 minutes, but in the case of pH 9 and 11, no material reduction in numbers of bacteria occurred. Upon examination of figures 3 and 4 it will be seen that the curves for the alkali alone and the alkali plus the chlorine are practically the same. At pH 13, of course, the

alkali plus the chlorine gave immediate sterilization, which was to be expected, inasmuch as the alkali alone at this concentration caused an equally rapid sterilization.

As the pH of drinking water and swimming pool is in the range of 6.8 to 8, an experiment was conducted, using pH values within this range, to determine whether or not any differences in degree of lag phase were found. Accordingly, pH values of 6.8, 7.2, 7.6, and 8 were tested. A residual chlorine content of 0.3 p.p.m. was used. The

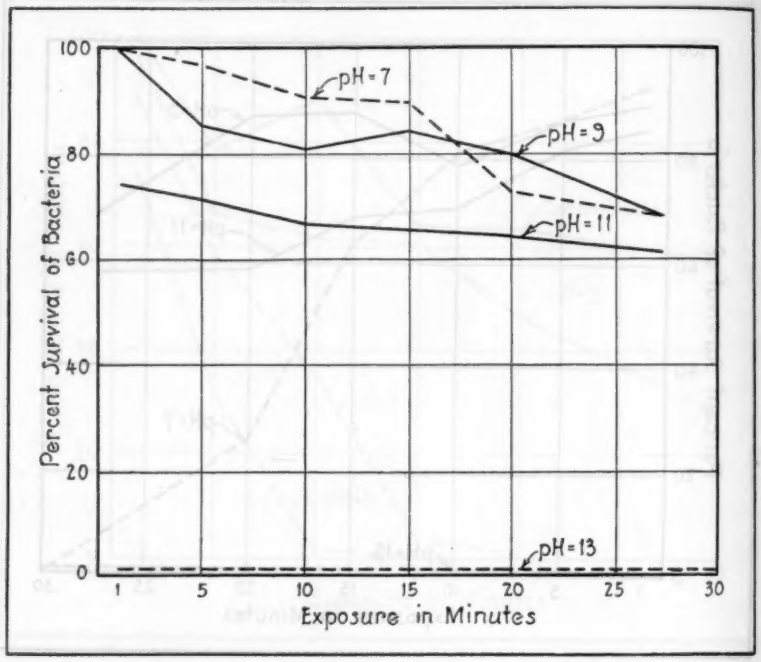


FIG. 4. THE GERMICIDAL POWER OF THE HYDROXYL ION ALONE ON ESCHERICHIA COLI

results are presented in figure 5. At pH 6.8, sterilization was effected in 30 minutes; at pH 7.2, 12 percent of the bacteria survived; at pH 7.6, 25 per cent of the bacteria survived; and at pH 8, 45 percent of the bacteria withstood the 30-minute exposure period. The results thus show that increasing alkalinities with a constant chlorine content cause decreasing rate of death in the germicidal action of the chlorine.

Knowing that marked decrease in the killing rate occurred in

alkaline solution, an attempt was made to determine the effect of increasing the chlorine content at a constant pH value. Accordingly, at pH 9, contents of 0.3, 0.6, 1.2, and 2 p.p.m. availaole chlorine were tested for the killing speed on *Staphylococcus aureus*. The results are presented in figure 6. With 0.3 p.p.m. available chlorine, 13 percent of the organisms survived 30 minutes exposure; with 0.6 p.p.m. sterilization was obtained in 15 minutes; and with 1.2 and

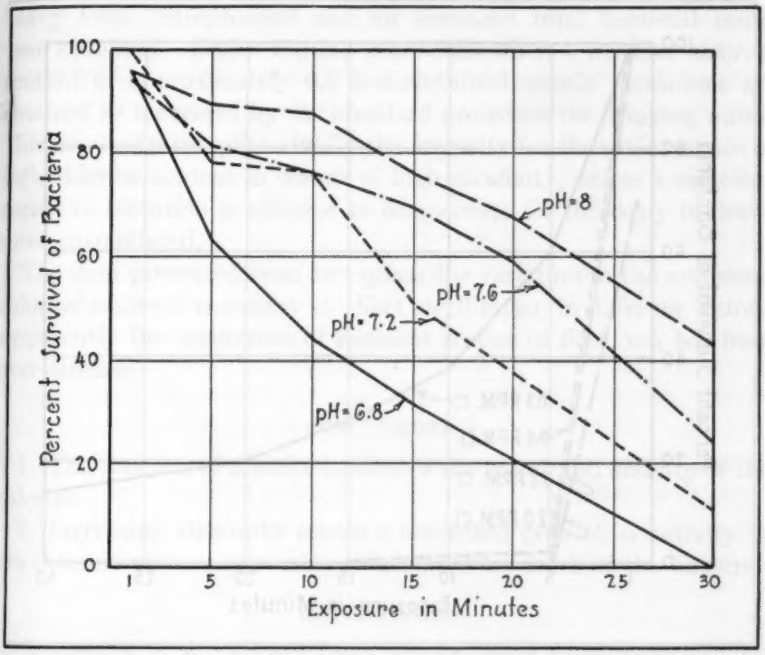


FIG. 5. THE INFLUENCE OF SLIGHT CHANGES IN THE HYDROGEN ION CONCENTRATION ON ESCHERICHIA COLI IN THE PRESENCE OF 0.2 P.P.M. AVAILABLE CHLORINE

2 p.p.m., sterilization was effected in 5 minutes. These data show that, although marked decreased rates of death are evident in alkaline solution, still an increase of chlorine offsets the effect and allows effective sterilization.

The data presented in this paper clearly demonstrate from a laboratory standpoint the significance of reaction of the water in the sterilization process. It is understood, of course, that in such studies large numbers of organisms are used in order that the resulting

death rates can be determined over a longer period of time. The fact that, in these experiments, it took 30 minutes to kill *Esch. coli* at pH 7 in the presence of 0.2 p.p.m. available chlorine, does not mean that a similar period would be necessary in a water supply to kill a much smaller number of cells. It does mean, however, that the time period for killing these organisms at pH 7 would be much less than at pH 8.

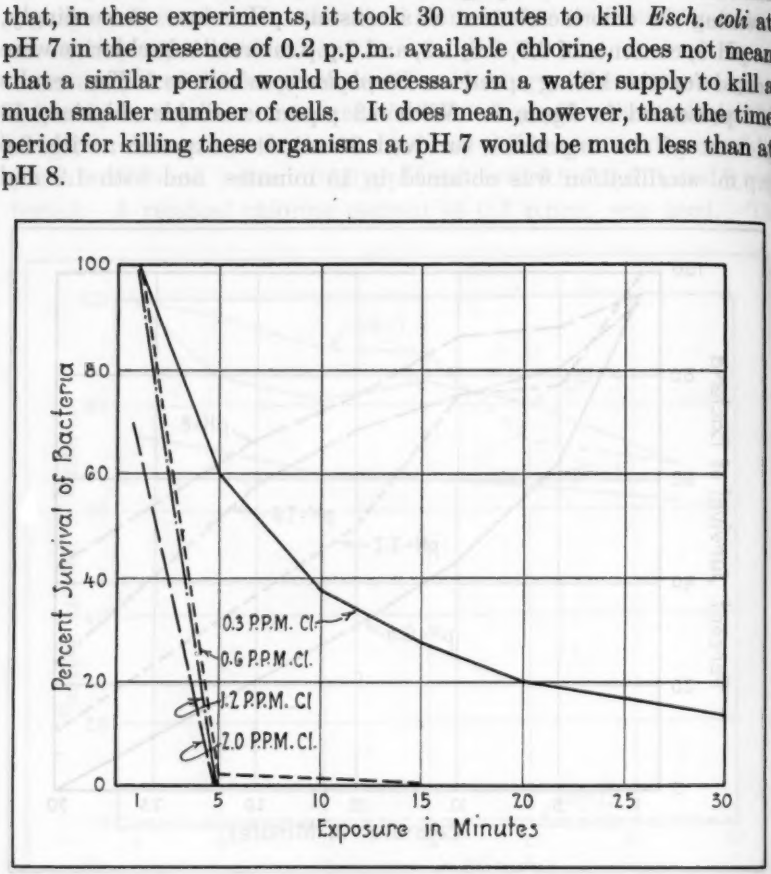


FIG. 6. THE INFLUENCE OF INCREASING CONTENTS OF AVAILABLE CHLORINE ON GERMICIDAL ACTION AT A CONSTANT pH-9 ON STAPHYLOCOCCUS AUREUS

This means that the necessary killing dose of chlorine is dependent upon the reaction of the water to be disinfected. As the pH value of the water increases, the amount of chlorine must also increase, if the killing time is to be kept constant. This is, of course, particularly important under conditions where the killing time must be immediate. To cite an example, in a swimming pool using chlorine disinfection, purity is dependent largely upon the available residual chlorine in the pool. As fast as the bacteria are removed from the body of the bather, they should come in contact with a germicidal

dose of chlorine which should kill them instantaneously. Failure to effect immediate destruction means a gradually increasing bacterial content that may eventually reach a concentration that would endanger the bather. This is particularly true of the gram-positive organisms, i.e. streptococci. A practical demonstration of this was obtained by reducing the residual chlorine content of the college pool, which has a reaction of pH 7.8 to 8.2, to 0.3 p.p.m. available chlorine and by testing the pool every 15 minutes during a period of heavy load. Streptococci and an increased total bacterial count were obtained. Under routine conditions when a residual chlorine content of approximately 0.5 is maintained, sterile conditions are obtained as measured by the standard procedure for drinking water. This demonstrates quite vividly the necessity for the maintenance of high chlorine content in waters of high alkalinity, unless a sufficient period of retention is afforded to compensate for the delay in death rates encountered.

The data presented seem to explain the variation in the minimum chlorine contents necessary to effect sterilization in different waters. Apparently the occurrence of resistant strains of *Esch. coli* has been over-stressed.

CONCLUSIONS

1. The reaction of a water influences the germicidal activity of the chlorine.

2. Increasing alkalinity causes a decreased germicidal activity of the chlorine with an increasing time period for death of the bacteria.

REFERENCES

(1) HOLWERDA, K. A.: Mededeelingen von den Dienst Volkesgezondheid, 17: 251, 1928.

(2) MALLMANN, W. L., AND GELPI, A. J.: Mich. Agricultural Exp. Sta. Tech. Bull., 27, 1930.

(3) RIDEAL, E. K., AND EVANS, V. R.: Jour. Soc. Chem. Ind., 40: 64R, 1921.

COTTON GUARD ROPE IN SWIMMING POOLS AS SOURCE OF COLON-AEROGENES GROUP

By H. W. Leahy[1]

The practice of sterilizing swimming pool water by combined filtration and chlorination has usually been found satisfactory in destroying bacteria of the colon-aerogenes group. Several workers, however, have found the presence of these organisms in water containing fairly large quantities of free chlorine. Mallmann and Gelpi (1), for example, found high bacteria counts and the presence of the colon group in a swimming pool water containing 0.1 to 0.2 p.p.m. of chlorine, and claimed that the presence of these organisms was due to their high tolerance toward chlorine. On the other hand, unusual conditions such as leather washers (2), (3) and pump packing (4) have been shown to be a source of the colon-aerogenes group in water supplies. The most recent example of such conditions is perhaps that described by Spaulding (5) who showed that the jute packing used to yarn the joints of the cast iron water mains was the source of the organisms giving rise to positive colon-aerogenes tests in samples taken from newly laid pipe. In this case treatment of the pipe-lines with strong chlorine solution (180 p.p.m.) followed by flushing was not successful in eliminating the offending organisms. This paper describes a similar condition in a swimming pool giving rise to positive tests for the colon-aerogenes group while the water contained a residual of between 0.2 and 0.4 p.p.m. of free chlorine.

This condition occurred in the new indoor swimming pool of the University of Rochester. This pool is 30 feet wide by 75 feet long and ranges in depth from 3 to 9 feet. It is equipped with filtration and chlorinating apparatus which is operated from 13 to 14 hours per day; the water recirculating at the rate of about 22,900 gallons per hour. Since the capacity of the pool is 127,000 gallons, there is a complete turn-over once in every 5.5 hours, or 2.3 times a day. The

[1] Sanitary Bacteriologist and Chemist, Rochester Health Bureau Laboratories, Department of Bacteriology, School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.

temperature of the water is maintained at 71 to 74°F. by means of an indirect heating system, and a residual free chlorine of 0.2 to 0.5 p.p.m. is maintained. Daily examinations of the water for total count, colon-aerogenes group, free chlorine and pH are used as a check on the operation of the pool. Samples are examined within 0.5 hour after collection.

Operating the pool on this policy had always given satisfactory results prior to November 10, 1931. The average bacterial plate count before this date was one per cubic centimeter, the average chlorine content was 0.40 p.p.m., the average pH was 6.8 and no positive presumptive tests had ever been obtained. On November 10, however, one out of five of the 1 cc. tubes planted in lactose broth showed a positive presumptive test in 24 hours, which upon partial confirmation gave the typical aerogenes type of colonies on eosine-methylene-blue agar plates. On November 11 and 12 the same conditions were found, and the operator was questioned. From him it was learned that on November 6, the athletic instructor had installed a large three-stranded cotton rope across the pool midway between the shallow and deep ends to act as a guard-rope for beginners. This rope hung in the pool in such a way that about 25 feet of it was immersed in the water, and in so far as could be determined this was the only change in the condition of the pool.

Samples of the rope were requested and brought to the laboratory. The moist rope was plated on eosine-methylene-blue agar plates, strands being taken from the interior of the rope with sterile forceps. Streaking the plates with these strands and incubating 24 hours at 37°C. gave a large number of typical aerogenes colonies. Upon transferring these large juicy colonies to secondary lactose broth and plain agar slants, the presence of the colon-aerogenes group was confirmed. Further cultural examinations of the two strains isolated showed them to be Voges-Proskauer positive, methyl red negative, sodium citrate positive, and indole negative. The organism fermented glucose, lactose, sucrose, salicin and glycerine with the production of both acid and gas.

After finding the presence of the colon-aerogenes group in the rope, it was thought of value to obtain some quantitative data on the growth of the bacteria on the rope. In order to accomplish this, samples of the rope taken aseptically were placed in sterile dilution bottles containing 100 cc. of sterile tap water and plated on plain agar from day to day. The counts obtained in this manner showed

that after a preliminary decrease there was a steady increase in the number of bacteria, thus illustrating the ability of the bacteria to grow upon the moist rope.

On the first day 1 cc. of the above dilution water from each bottle was also seeded into cellulose nitrate medium (6) and Tetrault's cellulose medium (7), both aerobic and anaerobic cultures being prepared. It was thought at first that cellulose digesters if present in

TABLE 1

University of Rochester swimming pool—laboratory results

DATE, NOVEMBER, 1931	PLATE COUNT, 24 HOURS AT 37°C.	PRESUMPTIVE TEST FOR COLON-AEROGENES GROUP	FREE CHLORINE	pH
			p.p.m.	
2	0	Negative	0.30	6.7
3	0	Negative	0.30	6.8
4	0	Negative	0.20	6.9
5	1	Negative	0.30	6.9
*6	0	Negative	0.25	
9	0	Negative	0.25	7.0
10	0	Positive	0.20	7.0
11	0	Positive	0.30	6.9
12	0	Positive	0.30	6.6
13	0	Positive	0.40	6.8
16	0	Positive	0.30	7.0
**17	1	Positive	0.30	6.9
18	0	Negative	0.40	7.1
19	0	Negative	0.30	6.9
20	0	Negative	0.40	7.0
23	0	Negative	0.50	6.7
24	0	Negative	0.50	6.8
25	0	Negative	0.30	6.8
27	2	Negative	0.50	6.7

* Rope guard placed in swimming pool.

** Rope guard replaced by chain guard.

the rope might break down enough of the cellulose into less complicated carbohydrates so that other bacteria could use the resulting sugars for growth. However, after 3 weeks incubation at 37°C., no cellulose digestion was evident in any of the tubes. As a consequence this theory was abandoned.

After finding the presence of the colon-aerogenes group in the rope it was requested that the rope be removed from the pool and either a

wire rope or a metal chain be substituted in its place. This was done on November 17, and immediately after its removal the positive presumptive tests disappeared. As is shown in table 1 there is a direct and striking correlation between the presence of the colon-aerogenes organisms in the swimming pool samples and the presence of the rope in the pool. In addition the finding of this same group of organisms in large numbers in the rope itself would seem to prove that the rope was the source of the contamination.

We were unable to procure samples of new rope from the same source from which the above sample was obtained. Consequently we cannot say whether the bacteria existed upon the rope before placing in the pool or whether it became contaminated afterwards.

Guard ropes made of organic material are unsuitable for use in swimming pools. They provide crevices containing organic material in which bacteria of the colon-aerogenes group, protected against the killing action of chlorine, can multiply. These organisms derived from such a contaminated rope escape into the water of the pool.

REFERENCES

(1) MALLMANN, W. L., AND GELPI, A. G., JR.: Chlorine resistance of colon bacilli and streptococci in a swimming pool. Michigan Eng. Expt. Sta. Bull., No. *27*, 3–16 (1930); also Chem. Abst., *24*, 2527 (1930).

(2) GERSTEIN, H. H.: Bacteria growing on leather packing cause errors in sampling. Eng. News-Record, *101*, 407 (1928).

(3) GREER, F. E., AND KELLS, L. C.: Bacteria on leather washers; lactose-fermenting organisms growing on leather washers at Chicago. Water Works and Sewerage, *76*, 391–2 (1929).

(4) SPAULDING, C. H.: Preammoniation at Springfield, Illinois. Jour. Amer. Water Works Assn., *21*, 1085–96 (1929).

(5) SPAULDING, C. H.: Contamination of mains by jute packing. Amer. Jour. Pub. Health, *21*, 1380–3 (1931).

(6) BRADLEY, LEON A., AND RETTGER, LEO F.: Studies on aerobic bacteria commonly concerned in the decomposition of cellulose. Jour. Bact., *13*, 321–45 (1927).

(7) TETRAULT, P. A.: The fermentation of cellulose at high temperatures. Zentralblatt f. Bakt., etc., II Abt., *81*, 28–45 (1930) (in English).

TYPHOID FEVER IN THE LARGE CITIES OF THE UNITED STATES IN 1931[1]

This report concerns the same ninety-three cities with a population of more than 100,000 that appeared in the corresponding report for 1930. The number of deaths from typhoid during 1931 in each city (except Scranton; see note to table 2) has been supplied by the respective health department. The rates are calculated on the basis of the population figures for July 1, 1931, as estimated by the United States Bureau of the Census, except in the few instances (noted in the tables) in which such estimates were not made. In the latter, the population figures of the 1930 federal census were employed. It should be noted that the figures for deaths from typhoid include all that have occurred within the city limits, of nonresident as well as residents, since statisticians are agreed that "the attempt to eliminate the deaths of nonresidents would often result in an understatement of the true mortality."[2] It is evident, however, that nonresident deaths offer an important problem in a number of localities. The cities in which one third or more of the typhoid deaths occurred in nonresidents are indicated in table 9.

The fairest way of dealing with the general problem of nonresident deaths would of course be to charge against the community only those deaths in which it could be shown that the disease or cause of death originated within the corporate limits. To these might properly be added those deaths of nonresidents in which similar relations could be proved. Any uniform and "fair" distribution of nonresident deaths is obviously difficult and in most cases impracticable. In a recent discussion of this problem in the Weekly Bulletin of the

[1] Reprinted from the Journal of the American Medical Association, 98:18, April 30, 1932, p. 1550. Preceding articles were published in the same Journal, May 31, 1913, p. 1702; May 9, 1914, p. 1473; April 17, 1915, p. 1322; April 22, 1916, p. 1305; March 17, 1917, p. 845; March 16, 1918, p. 777; April 5, 1919, p. 997; March 6, 1920; p. 672; March 26, 1921, p. 860; March 25, 1922, p. 890; March 10, 1923, p. 691; Feb. 2, 1924, p. 389; March 14, 1925, p. 813; March 27, 1926, p. 948; April 9, 1927, p. 1148; May 19, 1928, p. 1624; May 18, 1929, p. 1674; May 17, 1930, p. 1574, and May 9, 1931, p. 1576.

[2] Bureau of the Census, Mortality Statistics, 1912, p. 13.

New York Department of Health (Nov. 1, 1930) it is pointed out that many nonresidents suffering from cancer come to New York City for the sake of superior surgical and other facilities. The figures for 1929 show 169 New York citizens dying of cancer outside the city and 363 nonresidents dying of the disease in the city. In tuberculosis the situation, as one might suppose, is reversed, 465 New York city residents dying of the disease in places outside the city, while 92 nonresidents died of tuberculosis in the city. The deaths of nonresidents from automobile accidents afford another illustration.

TABLE 1

Death rates of cities in New England States from typhoid per hundred thousand population

	1931	1930	1926–1930	1921–1925	1916–1920	1911–1915	1906–1910
Cambridge	0.0	0.9	2.1	4.3	2.5	4.0	9.8
Fall River	0.0	2.6	2.2	2.3	8.5	13.4	13.5
Lynn	0.0	1.0	1.5	1.6	3.9	7.2	14.1
Somerville	0.0	1.9	1.3	1.6	2.8	7.9	12.1
Waterbury	0.0	1.0	1.2	1.0	8.0	18.8	
Worcester	0.5	0.0	1.0	2.3	3.5	5.0	11.8
Bridgeport	0.7	0.0	0.5	2.2	4.8	5.0	10.3
Boston	0.9	0.8	1.2	2.2	2.5	9.0	16.0
Lowell	1.0*	5.0	2.6	2.4	5.2	10.2	13.9
New Haven	1.2	0.0	0.6	4.4	6.8	18.2	30.8
Providence	1.6	2.0	1.3	1.8	3.8	8.7	21.5
New Bedford	1.8*	2.7	1.5	1.7	6.0	15.0	16.1
Springfield	2.6	0.7	0.4	2.0	4.4	17.6	19.9
Hartford	3.6	2.4	1.3	2.5	6.0	15.0	19.0

* Rate computed from population as of April 1, 1930, as no estimate for July 1, 1931, was made by the Census Bureau.

It is evident that in most cities in this country any attempt to correct general mortality tables by analyzing nonresident deaths would hardly be worth while. For certain specific diseases like typhoid, however, particularly in the smaller cities and in those communities where the disease is relatively infrequent, it is plain that the problem of nonresident deaths must be kept in mind in any comparative study. In five American cities, all the typhoid deaths reported in 1930 were stated to be those of nonresidents. In a number of others, one third or more of the reported typhoid deaths were stated to be of nonresidents. As pointed out in the previous report,

city typhoid rates in some parts of the United States at the present time are indicative of regional, rather than strictly municipal, conditions.

Five of the fourteen New England cities (Cambridge, Fall River, Lynn, Somerville, Waterbury) had no deaths from typhoid during 1931 (table 1). Boston apparently equals its good record of 1930 with a rate of less than 1 per hundred thousand. Lowell, which has

TABLE 2

Death rates of cities in Middle Atlantic states from typhoid per hundred thousand population

	1931	1930	1926–1930	1921–1925	1916–1920	1911–1915	1906–1910
Reading	0.0	0.9	1.6	6.0	10.0	31.9	42.0
Utica	0.0	0.0	1.1	3.9*			
Newark	0.2	0.2	0.9	2.3	3.3	6.8	14.6
Jersey City	0.3	0.3	0.9	2.7	4.5	7.2	12.6
Syracuse	0.5	0.5	0.8	2.3	7.7	12.3	15.6
Buffalo	0.7	3.9	2.7	3.9	8.1	15.4	22.8
Erie	0.8	0.9	0.9	2.3	6.9	49.0	46.6
Philadelphia	0.9	0.9	1.1	2.2	4.9	11.2	41.7
Rochester	0.9	1.8	1.7	2.1	2.9	9.6	12.8
New York	1.1	0.9	1.3	2.6	3.2	8.0	13.5
Pittsburgh	1.2	1.5	2.4	3.9	7.7	15.9	65.0
Yonkers	1.4	0.7	0.5	1.7	4.8	5.0	10.3
Trenton	1.6	2.4	2.1	8.2	8.6	22.3	28.1
Scranton	2.1†	1.4	1.8	2.4	3.8	9.3	31.5
Albany	2.3	0.8	1.8	5.6	8.0	18.6	17.4
Paterson	2.9	0.0	1.0	3.3	4.1	9.1	19.3
Camden	4.2	4.2	4.4	5.9	4.9	4.5	4.0
Elizabeth	4.3	4.4	1.6	2.4	3.3	8.0	16.6

* Data for 1925 only.

† Typhoid deaths for Scranton furnished by Pennsylvania Department of Health, Harrisburg.

not had an enviable typhoid picture in recent years, reports a much lower figure for 1931. Springfield, which was the banner city for the period 1926–1930, did not do as well in 1931, and Hartford shows an average typhoid rate for 1930 and 1931 considerably higher than the average for the preceding ten years.

The typhoid rate for the New England group as a whole is, with one exception (1928), the lowest ever recorded (table 12). These cities have improved their condition relatively with respect to the

TABLE 3

Death rates of cities in South Atlantic states from typhoid per hundred thousand population

	1931	1930	1926–1930	1921–1925	1916–1920	1911–1915	1906–1910
Richmond	1.6	2.2	1.9	5.7	9.7	15.7	34.0
Miami	1.8	1.8	3.5				
Wilmington	1.9*	4.7	3.1	4.7	25.8†	23.2‡	33.0
Jacksonville	3.0	0.0	4.4				
Baltimore	3.1	3.3	3.2	4.0	11.8	23.7	35.1
Tampa	3.8	3.0	3.8	19.1	43.9§		
Washington	3.9	3.3	2.8	5.4	9.5	17.2	36.7
Norfolk	5.4*	3.8	2.2	2.8	8.8	21.7	42.1
Atlanta	12.6	10.3	11.1	14.5	14.2	31.4	58.4

* Rate computed from population as of April 1, 1930, as no estimate for July 1, 1931, was made by the Census Bureau.

† Data for 1916 only.

‡ Lacks data for 1913.

§ Lacks data for 1916.

TABLE 4

Death rates of cities in East North Central states from typhoid per hundred thousand population

	1931	1930	1926–1930	1921–1925	1916–1920	1911–1915	1906–1910
Flint	0.0	0.6	1.6	4.6	22.7	18.8	46.9
South Bend	0.0	0.0					
Milwaukee	0.3	0.3	0.8	1.6	6.5	13.6	27.0
Chicago	0.4	0.6	0.6	1.4	2.4	8.2	15.8
Cincinnati	0.4	2.4	2.5	3.2	3.4	7.8	30.1
Dayton	0.4	0.5	1.9	3.3	9.3	14.8	22.5
Detroit	0.7	1.1	1.3	4.1	8.1	15.4	22.8
Evansville	0.9	6.8	6.2	5.0	17.5	32.0	35.0
Grand Rapids	1.2	0.6	1.0	1.9	9.1	25.5	29.7
Akron	1.5	1.2	1.5	2.4	10.6	21.0	27.7*
Indianapolis	1.6	1.9	2.7	4.6	10.3	20.5	30.4
Fort Wayne	1.7	2.6	4.2	12.9	7.3		
Youngstown	1.7	2.3	1.1	7.2	19.2	29.5	35.1
Peoria	1.8	0.0	0.2	3.7	5.7	16.4	15.7†
Canton	1.9	1.9	1.4	3.3	8.9		
Toledo	2.0	2.1	3.0	5.8	10.6	31.4	37.5
Columbus	2.4	2.7	2.1	3.5	7.1	15.8	40.0
Cleveland	3.4	1.5	1.0	2.0	4.0	10.0	15.7

* Data for 1909 and 1910 only.

† Lacks data for 1907, 1908 and first four months of 1909.

Middle Atlantic group, the rates this year being almost identical in the two sections.

The cities in the Middle Atlantic states, by far the most populous of the eight geographic groups, had an average rate in 1931 almost exactly like that in 1930 (table 2). Reading and Utica had no ty-

TABLE 5

Death rates of cities in East South Central states from typhoid per hundred thousand population

	1931	1930	1926–1930	1921–1925	1916–1920	1911–1915	1906–1910
Chattanooga	1.6	0.8	8.0	18.6	27.2	35.8*	
Louisville	2.6	1.6	3.7	4.9	9.7	19.7	52.7
Birmingham	3.0	4.6	8.0	10.8	31.5	41.3	41.7
Nashville	3.2	12.3	18.2	17.8	20.7	40.2	61.2
Knoxville	7.3	1.9	10.7	20.8	25.3†		
Memphis	7.3	4.7	9.3	18.9	27.7	42.5	35.3

* Data for 1914 and 1915 only.

† Data for 1920 only.

TABLE 6

Death rates of cities in West North Central states from typhoid per hundred thousand population

	1931	1930	1926–1930	1921–1925	1916–1920	1911–1915	1906–1910
Des Moines	0.0	1.4	2.4	2.2	6.4	15.9	23.7
Wichita	0.0	1.8	1.2	6.3			
Minneapolis	0.6	1.3	0.8	1.9	5.0	10.6	32.1
Duluth	1.0	2.0	1.1	1.7	4.4	19.8	45.5
St. Paul	1.1	0.7	1.4	3.4	3.1	9.2	12.8
Kansas City, Mo.	1.5	2.2	2.8	5.7	10.6	16.2	35.6
Kansas City, Kan.	1.6	0.0	1.7	5.0	9.4	31.1	74.5*
Omaha	1.8	0.9	1.3	3.3	5.7	14.9	40.7
St. Louis	2.0	2.5	2.1	3.9	6.5	12.1	14.7

* Lacks data for 1906 and 1907.

phoid deaths in 1931, the latter repeating its perfect record for the second successive year. Paterson on the other hand, which had no typhoid deaths in 1930, records a rate of 2.9 in 1931. Newark, Jersey City, Syracuse, Philadelphia and Camden had the same rates for 1931 as for 1930, and Erie, New York and Elizabeth had rates substantially the same for the two years. Buffalo shows an encour-

aging decrease from 3.9 to 0.7. Camden and Elizabeth again bring up the bottom of the list as they did in 1930. The increase in New York, small, to be sure, but worth noting, seems to be chiefly due to

TABLE 7

Death rates of cities in West South Central states from typhoid per hundred thousand population

	1931	1930	1926–1930	1921–1925	1916–1920	1911–1915	1906–1910
Tulsa	2.0	2.1	8.3	16.2*			
Houston	3.2	3.8	4.8	7.6	14.2	38.1	49.5†
San Antonio	4.2	3.9	4.6	9.3	23.3	29.5	35.9
El Paso	4.8	6.8	9.1	10.8	30.7	42.8	
Fort Worth	5.4	4.9	5.9	6.1	16.3‡	11.9	27.8
Oklahoma City	5.6	7.0	7.4§				
Dallas	7.3	6.5	7.3	11.2	17.2		
New Orleans	13.9	6.5	9.9	11.6	17.5	20.9	35.6

* Lacks data for 1921 and 1922.
† Data for 1910 only.
‡ Lacks data for 1918 and 1919.
§ Lacks data for 1926.

TABLE 8

Death rates of cities in Mountain and Pacific states from typhoid fever per hundred thousand population

	1931	1930	1926–1930	1921–1925	1916–1920	1911–1915	1906–1910
Long Beach	0.0	0.7	1.1	2.1*			
Seattle	0.5	2.2	2.2	2.6	2.9	5.7	25.2
San Diego	0.6	0.0	1.0	1.6	7.9	17.0	10.8
Los Angeles	0.7	1.5	1.5	3.0	3.6	10.7	19.0
Spokane	0.8	1.7	2.2	4.4	4.9	17.1	50.3
Tacoma	0.9	0.9	1.8	3.7	2.9	10.4	19.0
Oakland	1.0	1.0	1.2	2.0	3.8	8.7	21.5
Portland	1.0	1.0	2.3	3.5	4.5	10.8	23.2
Salt Lake City	1.4	2.8	1.9	6.0	9.3	13.2	41.1
San Francisco	1.4	1.3	2.0	2.8	4.6	13.6	26.3
Denver	3.4	2.1	2.6	5.1	5.8	12.0	37.5

* Lacks data for 1921.

three outbreaks during the second quarter of 1931 caused by unregistered carriers. The skill and thoroughness with which these outbreaks were traced to food handlers are worthy of emulation. More than half of the typhoid cases occurring in New York, in which

TABLE 9

Death rates from typhoid in 1931

Honor Roll: No typhoid deaths

Cambridge	Long Beach	South Bend
Des Moines	Lynn	Utica
Fall River	Reading	Waterbury
Flint	Somerville	Wichita

First Rank (from 0.1 to 1.9 deaths per hundred thousand)

Newark 0.2	Boston 0.9	Akron 1.5
Jersey City 0.3*	Evansville 0.9	Kansas City, Mo. 1.5†
Milwaukee 0.3	Philadelphia 0.9	Chattanooga 1.6
Chicago 0.4	Rochester 0.9*	Indianapolis 1.6
Cincinnati 0.4	Tacoma 0.9	Kansas City, Kan. 1.6*
Dayton 0.4	Duluth 1.0	Providence 1.6†
Seattle 0.5	Lowell 1.0	Richmond 1.6†
Syracuse 0.5	Oakland 1.0†	Trenton 1.6†
Worcester 0.5	Portland 1.0	Fort Wayne 1.7
Minneapolis 0.6†	New York 1.1	Youngstown 1.7†
San Diego 0.6*	St. Paul 1.1	Miami 1.8
Bridgeport 0.7	Grand Rapids 1.2†	New Bedford 1.8
Buffalo 0.7†	New Haven 1.2†	Omaha 1.8
Detroit 0.7	Pittsburgh 1.2†	Peoria 1.8†
Los Angeles 0.7	Salt Lake City 1.4	Canton 1.9
Erie 0.8	San Francisco 1.4†	Wilmington 1.9
Spokane 0.8*	Yonkers 1.4	

Second Rank (from 2.0 to 4.9)

St. Louis 2.0	Paterson 2.9	Hartford 3.6†
Toledo 2.0	Birmingham 3.0†	Tampa 3.8
Tulsa 2.0	Jacksonville 3.0	Washington 3.9
Scranton 2.1	Baltimore 3.1	Camden 4.2†
Albany 2.3	Houston 3.2	San Antonio 4.2†
Columbus 2.4†	Nashville 3.2	Elizabeth 4.3
Louisville 2.6	Cleveland 3.4	El Paso 4.8
Springfield 2.6	Denver 3.4	

Third Rank (from 5.0 to 9.9)

Fort Worth 5.4	Oklahoma City 5.6	Knoxville 7.3
Norfolk 5.4	Dallas 7.3†	Memphis 7.3†

Fourth Rank (10.0 and Over)

Atlanta 12.6†	New Orleans 13.9†

* All the typhoid deaths reported were stated to be in nonresidents.

† One third or more of the reported typhoid deaths were stated to be in nonresidents.

the probable mode of infection could be traced, were apparently contracted outside the city.

Five of the nine cities in the South Atlantic group had higher rates in 1931 than in 1930 and one (Miami) was stationary (table 3). Norfolk again shows an increase and bids fair to have a higher average for the 1930 quinquennium than for the preceding ten years. Washington also is not quite maintaining its excellent 1926–1930 average.

The cities in the East North Central group (tables 4 and 12) lead all the others in their low typhoid average for 1931. This is in spite of the fact that in Cleveland twenty out of thirty-one deaths occurred in an outbreak at the State Hospital for the Insane. Without these

TABLE 10

Number of cities with various typhoid death rates

	NUMBER OF CITIES	10.0 AND OVER	5.0 TO 9.9	2.0 TO 4.9	1.0 TO 1.9	0.1 TO 0.9	0.0
1906–1910	77	75	2	0	0	0	0
1911–1915	79	58	19	2	0	0	0
1916–1920	84	22	32	30	0	0	0
1921–1925	89	12	17	48	12	0	0
1926–1930	92	3	10	30	37	12	0
1926	91	9	13	28	20	15	6
1927	92	6	10	28	27	13	8
1928	92	5	9	29	22	17	10
1929	92	2	9	21	27	25	8
1930	93	2	6	30	23	22	10
1931	93	2	6	23	28	22	12

deaths, the Cleveland rate would be 1.2 instead of 3.4, as given in table 4. The rates in Milwaukee, Chicago and Cincinnati continue amazingly low. South Bend, which was first reported among the cities with a population of over 100,000 in 1930, ends its second consecutive year without a death. Detroit seems definitely to have come out of its typhoid period and ranks among the best. This great group of Middle Western cities with nearly 10,000,000 population appears headed toward an almost complete elimination of typhoid.

The cities in the East South Central states have, as is well known, a more difficult problem than those in some other parts of the country. The great reduction in the Nashville rate for 1931 is especially noteworthy (table 5). This is by far the lowest rate ever reported

in that city. Birmingham also breaks its lowest previous record. Memphis, on the other hand, shows an increase and Knoxville is also a backslider.

TABLE 11

*Total typhoid rate for seventy-eight cities, 1910–1913**

	POPULATION	TYPHOID DEATHS	TYPHOID DEATH RATE PER 100,000
1910	22,573,435	4,637	20.54
1911	23,211,341	3,950	17.02
1912	23,835,399	3,132	13.14
1913	24,457,989	3,285	13.43
1914	25,091,112	2,781	11.08
1915	25,713,346	2,434	9.47
1916	26,257,550	2,191	8.34
1917	26,865,408	2,016	7.50
1918	27,086,696†	1,824†	6.73
1919	27,735,083†	1,151†	4.15
1920	28,244,878	1,088	3.85
1921	28,859,062	1,141	3.95
1922	29,473,246	963	3.26
1923	30,087,430	950	3.16
1924	30,701,614	943	3.07
1925	31,315,598	1,079	3.44
1926	31,929,782	907	2.84
1927	32,543,966	648	1.99
1928	33,158,150	628	1.89
1929	33,772,334	537	1.59
1930	34,386,717	554	1.61
1931‡	35,137,915	563	1.60

* The following fifteen cities are omitted from this table because data for the full period are not available: Canton, Chattanooga, Dallas, Fort Wayne, Jacksonville, Knoxville, Long Beach, Miami, Oklahoma City, South Bend, Tampa, Tulsa, Utica, Wichita, Wilmington.

† Data for Fort Worth lacking.

‡ The rate for the ninety-three cities in 1931 is 1.68 (total population, 37,145,012; typhoid deaths, 623), whereas in 1930 the corresponding rate was 1.64.

The cities in the West North Central states make their best group record (table 6), Des Moines and Wichita getting a place on the honor roll, while Minneapolis, Duluth and St. Paul are not far behind. St. Louis continues its excellent record.

The cities in the West South Central states are, as heretofore,

relatively high in typhoid as compared with those in other parts of the country (table 7), the average for the group in 1931 being about seven times as high as the averages for the cities in the New England, Middle Atlantic, East North Central and Mountain and Pacific groups. The increased rate in 1931 appears to be due largely to the increase in the New Orleans rate. This city, however, is apparently one of those suffering from a high nonresident rate, forty-eight of the sixty-five typhoid deaths in 1931 being reported as among nonresidents. Dallas again seems to have more of a typhoid problem than

TABLE 12

Total typhoid death rate per hundred thousand population for ninety-three cities according to geographic divisions

	1931 POPULATION	1931 TYPHOID DEATHS	TYPHOID DEATH RATES			
			1931	1930	1926–1930	1925
New England	2,617,705	28	1.07	1.23	1.31	2.48
Middle Atlantic	12,866,100	137	1.06	1.03	1.40	2.97
South Atlantic	2,352,107	101	4.29	3.87	4.50	7.01*
East North Central	9,585,300	96	1.00	1.14	1.29†	2.32†
East South Central	1,223,300	50	4.09	4.25	8.31	13.00
West North Central	2,688,600	36	1.34	1.74	1.83	3.43
West South Central	1,905,700	133	6.97	5.34	7.32‡	13.08§
Mountain and Pacific	3,906,200	42	1.07	1.43	1.80	2.33

* Lacks data for Jacksonville and Miami.

† Data for South Bend for 1925–1929 are not available.

‡ Lacks data for Oklahoma City in 1926.

§ Lacks data for Oklahoma City.

Houston, San Antonio or Fort Worth. The El Paso rate seems to be coming down satisfactorily.

The cities in the Mountain and Pacific states (table 8) make a particularly good record in 1931, nearly all of them showing rates as good as or better than those for 1930, thus bringing the group as a whole into close competition with the Eastern states. Denver, however, is out of line and had a higher rate in 1931 than its 1926–1930 average.

Twelve of the ninety-three cities state that no typhoid deaths occurred within their limits in 1931 (table 9). This is the largest number of cities with perfectly clear records ever reported in these summaries.

The total typhoid rate for the seventy-eight cities whose records are available for the whole twenty-one year period is almost exactly the same as for the two preceding years. It is too soon to conclude that a stable period in the urban typhoid rate has been reached for the whole country. In the light of past experience, it seems probable that a further decline will be witnessed. Tables 10 and 11 bear eloquent testimony to the astonishing improvement in typhoid prevalence that has taken place.

SOCIETY AFFAIRS

THE PACIFIC NORTHWEST SECTION

The fifth annual meeting of the Pacific Northwest Section was held in Wenatchee, Washington, May 12, 13, 14, 1932 with approximately 100 members and guests in attendance.

The meeting opened on May 12 with a Golf Tournament at the Wenatchee Golf and Country Club. Prizes were won by R. W. Martindale, Fred Shaneman, Ben S. Morrow, C. M. Sigle, D. A. Dunkle, T. E. Moffitt, George Sibbetts, C. G. Ehle, Hugh Purcell, H. D. Fowler and E. W. Thompson.

At the same time the Round Table discussion was held at the Meeting Headquarters, Cascadian Hotel, where the following subjects were discussed:

(1) Water hammer experience in gravity lines and pump lines.
(2) Why do you use the kind of pipe joining materials you are now using?
(3) How accurate should a meter be and how often should meters be read, monthly, bi-monthly or quarterly, and how often should they be removed for testing?
(4) Discussion of various service pipe materials.
(5) Group insurance.
(6) Hand digging versus trench machine.
(7) Are leak surveys justified?
(8) Should a school for filtration operators be conducted by the Pacific Northwest Section?

At the business meeting held in the evening of May 14, the following officers and trustees were elected: Chairman, H. V. Gates, President, Hillsboro Power and Investment Company, Hillsboro, Oregon; Vice-Chairman, Carl F. Klapp, Hydraulic Engineer, Everett, Washington; National Director, Ben S. Morrow, Chief Engineer, Bureau of Water Works, Portland, Oregon; Secretary-Treasurer, Ernest C. Willard, Consulting Engineer, Portland, Oregon; Trustee, W. P. Hughes, Superintendent Water Department and City Engineer, Lewiston, Idaho and Trustee, (Hold-over) Alex Lindsey, Superintendent, Water Department, Spokane, Washington.

The reports of the Secretary and Treasurer were read and approved at this meeting, following which an address was given by H. S. Rogers, Dean of the School of Engineering and Mechanical Arts, Oregon State College, Corvallis, Oregon, covering the life of Sextus Julius Frontinus, the Premier Water Superintendent who was Superintendent of the aqueducts of Rome under the Emperor Nerva.

This address was followed with a discussion by Ben S. Morrow, Chief of the Water Bureau, Portland, Oregon, on "What the Public has a Right to Expect from the Water Works Management."

The technical meeting held on May 13, opened with an address of welcome by the Honorable John S. Mooney, Mayor of Wenatchee, to which a response was given by Fred J. Sharkey, Chairman of the Section, after which the following program was presented:

"Design and Construction of West Seattle Reservoir," by Samuel De Moss, Consulting Engineer, Seattle, Wash.

"Purification of Snake River Water," by W. P. Hughes, City Engineer and Water Superintendent, Lewiston, Idaho.

"Rainfall and Run-off in the Pacific Northwest," by Richard G. Tyler, Dean of College of Engineering, University of Washington, Seattle, Washington.

"The History, Development and Special Problems of the Water System of Wenatchee, Washington," by Fred J. Sharkey, City Engineer, Wenatchee, Washington.

"Some Observations and Notes on Utility Financing," by J. W. Cunningham, Consulting Engineer, Portland, Oregon.

"Effect of Interconnections of Electrical Circuits with Underground Piping Systems," by J. B. Downer, Engineer, Seattle Water Department, Seattle, Wash.

"The Chemical and Biological Properties of Pacific Northwest Waters," by H. W. Nightingale, State Sanitary Engineer, State of Washington, Seattle, Washington.

In the evening a dinner and entertainment was held, at which time a talk was given by George W. Pracy, President of the American Water Works Association.

On Saturday, May 14, an inspection trip was taken to the Filtration Plant of the Wenatchee System and also to the Rock Island Hydro-electric Development of the Puget Sound Power and Light Company on the Columbia River.

ERNEST C. WILLARD.
Secretary.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Rainfall Characteristics and Their Relation to Soils and Run-Off. C. S. JARVIS. Trans. Am. Soc. Civil Engineers, 95: 379, 1931. Summarized information regarding precipitation and its occurrence in various countries and latitudes; its relation to soils and run-off; vegetative, topographic, and physiographic features of watersheds; and resultant influence on designs of drainage structures and channels. Precipitation records for 820 key stations, selected from among about 10,000 available stations throughout the world, and evaporation records for some of these stations are presented. No marked progressive changes of climate, or of rainfall habits, have been noted during several centuries of record; but a definite clue to minor variations has been developed through study of short-period records. Adequate understanding of the cause-and-effect relation between rainfall and run-off must include the range of conditions which may influence the rate, sequence, and continuity of the various natural processes involved in the rain-producing cycle. Such conditions may include solar radiation, atmospheric circulation and convection, evaporation, expansion, cooling, condensation, deposition, percolation, stream flow, and the accretions of losses sustained en route. Relation between precipitation records at 9 different stations and sun-spot numbers is shown and author concludes that no relation of practicable use is demonstrated. This conclusion is not concurred in by those discussing the paper. Types, structure, color, and stage of geological development of soils and the culture they bear provide a supplemental record awaiting interpretation as to rainfall and run-off habits. Comparison of rainfall and evaporation statistics indicates normal relationship between these two phenomena. One outstanding factor emphasized is the progressive increase of precipitation with temperature. Classifications of soils by various authorities are quoted. In the **discussion** many valuable methods for predictions concerning soils and drought are explained, with particular reference to application of the BRUCKNER cycles to various portions of the U. S. Exhaustive bibliography of the subject is presented.—*H. E. Babbitt.*

---

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

Baldwin Filtration Plant, Cleveland, Ohio. J. W. ELLMS and others. Trans. Am. Soc. Civil Engineers, 95: 459, 1931. This plant, with nominal capacity of 165,000,000 gallons per day, is designed to supply water to the Metropolitan District of Cleveland. The most modern methods in art of water purification have been introduced. Plant includes largest covered concrete reservoir in the world, having capacity of 135,000,000 gallons. Paper is subdivided as follows: History and Development of the Project; General Description of Flow of Water; Hydraulic Data; Design; Construction; General Equipment; Completion of Plant; and Amount of Contracts and Analysis of Costs. Expenditure of approximately $10,000,000 was involved; engineering features should be of interest to all engaged in design and construction of works of this type. Descriptions are in considerable detail in order both to enable other engineers to grasp the essentials of design and construction and to indicate the magnitude of the work. Certain departures from older methods are featured, for instance the hydraulic-jump flumes for mixing intimately chemical solutions with water to be treated. Design of coagulating basins, providing a straight flow through them with no baffles, an improvement which has proved entirely satisfactory in practice, is another departure from existing methods. Use of sharply-sloping floors in the coagulating basins, for dual purpose of reducing height of outside walls and facilitating cleaning of the basins, is of practical importance. Novel methods of introducing and withdrawing water in the Baldwin Reservoir are described. The groined arches in the roof have the longest span constructed to date. The cost tables are valuable because they represent a careful and detailed analysis of all contracts involved in the construction and are so presented as to permit ready comparison with other places and times by use of properly adjusted factors. Interesting features of design include the large-size filter units of 4,000,000 gallons per day capacity; provision for adjusting height of wash water gutters; use of deep layers of gravel; use of minimum number of gages on the filters; hydraulic-jump mixing devices involving head loss of 2½ feet; application of coagulant in solution rather than by dry-feed, contrary to present-day tendencies; conservative nominal rate of filtration of 125,000,000 gallons per acre per day; wash water rise of 21 to 26 inches; and effective sizes of sand between 0.35 and 0.42 mm. An additional feature of operation, not originally contemplated, has been the adoption of the ammonia-chlorine process of disinfection. Information is presented in such unusual detail as to be of value to designers and constructors of other plants. Cost data are of special value and are highly praised in the discussion. —*H. E. Babbitt.*

Frequency and Intensity of Excessive Rainfalls at Boston, Massachusetts. C. W. SHERMAN. Trans. Am. Soc. Civil Engineers, 95: 951, 1931. Paper presents results of study of records of recording rain-gage at Chestnut Hill Reservoir, covering a term of 50 years, and including durations of heavy rain up to 72 hours. Curves of intensity of precipitation, corresponding to any period of time up to 72 hours, for various frequencies of occurrence are derived and discussed. The form of curve showing relation between duration and average intensity of precipitation is discussed, and possibility of application to other localities of general formula derived, with coefficients and exponents suitably modified, is suggested. General form of equation developed is

$$i = \frac{K}{(t + b)^d}$$

in which i is intensity of precipitation in inches per hour; t, the period of time in minutes; and K, b, and d are constants whose values for different conditions are tabulated.—*H. E. Babbitt.*

Evaporation as a Function of Insolation. BURT RICHARDSON. Trans. Am. Soc. Civil Engineers, 95: 996, 1931. Effect of insolation and measurement of the quantity of radiant heat imparted by the sun and sky to the water and to the bottom of a reservoir are dealt with. Three distinct methods for determining the value of insolation, in which the experimental results check within 5 percent, are developed. Where it is not possible to get a ratio of evaporation to insolation from pyrheliometer records, it is necessary to compute the insolation on the exterior of the earth's atmosphere and correct this quantity by a transmission coefficient for the earth's atmosphere and by a clearness factor. The evaporation formula,

$$E = \frac{I - S - C - B_r}{2.54\ L\ (1 + R)}$$

checks experimentally with observed evaporation in California, and, when applied to bodies of water outside of California, gives satisfactory results. E is the quantity of water evaporated; I is the quantity of radiant heat, in calories per minute, that reaches a certain area on the surface of the earth; S is the sensible heat, measured by the warming or cooling of the water; B_r is the radiation from water; L is the latent heat of evaporation; and R is the ratio convection:evaporation.—*H. E. Babbitt.*

Silting and Life of Southwestern Reservoirs. T. U. TAYLOR. Trans. Am. Soc. Civil Engineers, 95: 1060, 1931. Silt loads of several streams of the Southwest are cited to indicate importance of silt problem; necessity for comprehensive study of it is emphasized, in order to be prepared to meet water storage problems which will arise in the future. When silt-laden water strikes the back-water of a reservoir its velocity is reduced and the coarser material is deposited. This deposit continues to grow and to extend upstream. It may build up to the point where a substantial deposit, which would otherwise occupy space in reservoir, is above the flow line. Methods of preventing silt deposits in reservoirs are explained and it is pointed out that effect of withdrawal of water from low outlets will extend for only a short distance upstream. Problem of preventing silting of reservoirs is one which should be handled by organization qualified to deal with the stream as a whole, as effect of works to benefit one reservoir would benefit other reservoirs on same stream.—*H. E. Babbitt.*

Ice as Affecting Power Plants. Final Report of Committee of Power Division, Am. Soc. Civil Engineers. Trans. Am. Soc. Civil Engineers, 95: 1134, 1931. Ice troubles for water works are similar to those encountered by power plants. In considering adverse effects of ice on plant operation, discussion

has been assembled under following headings. (*A*) Lessened stream flow from lake, or reservoir, because of ice formation in outflow channel. (*B*) Ice accumulations in reservoirs. (*C*) Ice accumulations in approach canals and forebays. (*D*) Lessened head from rise in back water, caused by ice formation in outflow channels down-stream from power plant. (*E*) Difficulties of gate operation in sub-zero weather. (*F*) Ice formations, or jams, on spillway dams, tending to block them. (*G*) Ice formations on reservoir structures with varying levels in reservoir. (*H*) Ice thrust on hydraulic structures. (*I*) Ice clogging of racks. (*J*) Ice clogging of valves and turbines. (*K*) Ice on intake screens of steam plants. Definitions of 13 different kinds of ice formation are given. Physics of ice formation are discussed in detail and experiences at plants in Europe and in the U. S. are cited. Among methods of overcoming the difficulties which are discussed are included: (1) use of artificially produced heat and (2) design of racks to avoid difficulties. Lengthy bibliography with condensed abstracts is presented.—*H. E. Babbitt.*

High Dams. A Symposium. Trans. Am. Soc. Civil Engineers, 95: 130, 1931. **Past Experience With High Dams and Outlook for the Future.** A. J. WILEY. 130. Account of experience in the design of high dams is given, with comments that the higher dams of the future will be of solid masonry, gravity type, either arched or straight. As between a straight gravity dam and a dam of same section, arched in plan, preference is given to the latter, or so-called arched gravity dam. Between an arched gravity dam in which arch stresses are low, because of preponderence of gravity section, and a less-than-gravity section arch, in which arch action predominates, preference is given to the arched gravity type. Reasons for these preferences are presented, as also are some suggestions for the design of future high dams. **Classification, Selection, and Adaptation of High Dams.** D. C. HENNY. 139. Historical sketch of progress in construction of high dams is presented and examples are cited to show tendency towards the construction of high dams of earth, rockfill, and masonry. Foundation requirements of dams of these materials are discussed; conditions limiting height are analyzed; and sources of danger are considered, including floods, earthquakes, cracking of concrete, uplift, and tension in foundation. **High Dams: the Viewpoint of the Geologist.** F. L. RANSOME. 149. If rocks were entirely homogeneous, it would probably rarely, if ever, be necessary to call upon a geologist to examine a site for a high dam. As a matter of fact, rocks are never perfectly homogeneous for any considerable distance. In layered rocks of many sorts the lack of homogeneity is obvious. It is in the recognition and interpretation of such departures from homogeneity that chief usefulness of geologists in relation to dam sites lies. Fundamental requisites in the rocks at site for a high dam are that they should (1) be strong enough to withstand stresses transmitted from the structure; (2) be reasonably impervious; (3) neither change in volume, nor soften, nor dissolve, under action of water; and (4) not be subject to movements which would endanger the structure. The paper is devoted to consideration of the relation of various rocks and geological formations to these fundamental requisites. **Construction Methods and Plant Layout at Coolidge Dam, Arizona.** J. G. TRIPP. 159. In planning his procedure, contractor was faced with

unusual difficulties as to plant selection and as to choice of handling materials. There were three main groups of problems involved in laying out construction plant: (1) concrete; (2) excavation; and (3) general service, applying both to concrete and to excavation. Methods for solution of these problems are described. Sixty-four pages of discussion follow the four principal articles of the symposium.—*H. E. Babbitt.*

Spillway Discharge Capacity of Wilson Dam. L. G. PULS. Trans. Am. Soc. Civil Engineers, **95**: 316, 1931. Current meter measurements of discharge at Wilson Dam are described. Readings were taken at different gate openings between 3 feet and full gate and under two conditions, namely, no discharge and full discharge through adjacent spillways. Head on crest was 18 feet. Discharge quantities, together with calculated coefficients for the several partly-opened gates and also for full gate, are given.—*H. E. Babbitt.*

The Dehydration of Analytical Precipitates by Ignition. W. MIEHR, P. KOCH and J. KRATZERT. Z. angew. Chem., **43**: 250–4, 1930. From Chem. Abst., **24**: 2688, June 10, 1930. Temperature of at least 1200° is necessary, fully to dehydrate precipitates of alumina or aluminum phosphate. Silica can be dehydrated by heating over good blast lamp.—*R. E. Thompson.*

Causes and Prevention of Corrosion on Hydromachinery. RAY S. QUICK. Power, **71**: 347–50, 1930. From Chem. Abst., **24**: 2707, June 10, 1930. Corrosion is usually mechanical rather than chemical. In one case where power water was acid, corrosion was prevented by using stainless steel.—*R. E. Thompson.*

Some Notes on Water Softening. J. GORDON. Gas World, **92**: Coking Section, 2370, 10–13, 1930. From Chem. Abst., **24**: 2817, June 10, 1930. Plant at Lambton, England, is described. Caustic soda is the only softening agent employed. Continuation of softening in boiler is discussed.—*R. E. Thompson.*

Experience with Zeolite and Acid at Beacon St. Plant. J. H. WALKER and L. F. COLLINS. Power, **71**: 552–5, 1930; cf C. A., **24**: 448. From Chem. Abst., **24**: 2817, June 10, 1930. During 3½ years' operation no scale has formed and there have been no tube burn-outs. Forty parts per million of sulfuric acid are added to treated water to neutralize carbonate and 4.5 parts of phosphoric acid to precipitate calcium.—*R. E. Thompson.*

Silicic Acid Content and Boiler Feed Water. C. J. BLOK. Pharm. Tijdschr. Nederl.-Indië, **6**: 273–6, 1929; Wasser u. Abwasser, **27**: 10. From Chem. Abst., **24**; 2817, June 10, 1930. Feed water containing 52 p.p.m. gave heavy deposit on boilers. Formation of scale was prevented by use of small amounts of sodium hydroxide. Scale contained 3 percent silicic acid. WINKLER method for determination of silicic acid is recommended.—*R. E. Thompson.*

The Disinfectant Action of Pure and Crude Chloramine. AUGUST HIRSCHEGGER. Wien. med. Wochschr., **79**: 159–61; Wasser u. Abwasser, **26**: 173.

From Chem. Abst., **24**: 2818, June 10, 1930. No difference in disinfectant action on water was noted. Chloramine is a cheap, non-poisonous, efficient disinfectant.—*R. E. Thompson.*

The Prevention of Trouble Due to Aquatic Growths in Condenser Systems, with Special Reference to the Destruction of Mussels. D. V. ONSLOW. World Power, **13**: 379–81, 1930. From Chem. Abst., **24**: 2818, June 10, 1930. Chlorination is method generally used in Great Britain both for prevention and for destruction of aquatic growths in condenser tubes. The comparatively weak solution of chlorine has no corrosive effect on any part of condenser. Other plants use copper sulfate (1 part in 10,000 of water), which loosens spawn from pipes.—*R. E. Thompson.*

Copper and Silver Chloride Solutions in Water and Sewage Treatment. G. ORNSTEIN and R. KROKE. Gesundh.-Ing., **53**: 153, 1930. From Chem. Abst., **24**: 2818, June 10, 1930. A comparison of disinfecting action of chlorine, of chlorine and silver chloride, and of chlorine and silver nitrate. Chlorine alone was about as effective as chlorine plus silver salts in concentration used.—*R. E. Thompson.*

The Use of Peat and Powdered Wood in the Purification of Dye Wastes. WALTER OTTEMEYER. Gesundh.-Ing., **53**: 185, 1930. From Chem. Abst., **24**: 2820, June 10, 1930. Attempts were made to absorb several dyes from their solution with peat and powdered wood, determinations being made by measuring quantity of 0.001 percent solution of dye which could be passed through filter before filtrate became colored. Dyes were absorbed more effectively from neutral and acid solutions than from alkaline solutions. Peat proved to be the better absorbent.—*R. E. Thompson.*

Gas Main Under the Trave at Schlutup and the Gas Supply at Schlutup. H. NEUMANN. Gas. u. Wasserfach, **73**: 269–71, 1930. From Chem. Abst., **24**: 2861, June 10, 1930. Previous gas mains under river had failed by corrosion. New main was covered with seamless lead pipe, 5 millimeters thick, drawn down on pipe and edges burned together. Joints were also covered with lead. Asphalted jute wrapping was used over lead and outside protected by 1 x ¼-inch wood strips held by band iron.—*R. E. Thompson.*

Preparation and Burial Places for Coating-Test Specimens. SCOTT EWING. Oil and Gas J., **28**: 47, 86 and 135–6, 1930. From Chem. Abst., **24**: 2861, June 10, 1930. Full details given as to preparation and burying of test pieces of pipe coated with proprietary bituminous and asphaltic-emulsion coatings intended to protect gas pipe lines against corrosion. Forty-two coatings were applied, each to 60 pieces of pipe. Specimens will be taken up in 4 instalments. Work is being conducted by research associate appointed by American Gas Association in Bureau of Standards.—*R. E. Thompson.*

Study of Soil Action on Pipe Lines. G. N. SCOTT. Oil and Gas J., **28**: 47, 112 and 116, 1930. From Chem. Abst., **24**: 2872, June 10, 1930. Series of soil

corrosion tests initiated by American Petroleum Institute through research associate in Bureau of Standards is intended to bring special attention to influence of design, or structure, of protective coating upon its serviceableness in field.—*R. E. Thompson.*

Soil Characteristics and Corrosion. I. A. DENISON. Oil and Gas J., **28**: 47, 122 and 132, 1930. From Chem. Abst., **24**: 2872, June 10, 1930. Comparison was made of pipe line replacements in 32-mile section in southeastern Great Lakes region and character of soil in which pipe was laid. In general, acid soils are most corrosive, although well-drained acid soil is not necessarily corrosive. Corrosion is very marked in calcareous glacial drift which is impervious to water. Galvanic corrosion may also occur where highly acid soil lies in contact with alkaline glacial drift.—*R. E. Thompson.*

Protecting Inside and Outside of Pipe on Oklahoma City Line. J. H. DAMERON. Petroleum Engineer, **1**: 6, 36–8, 40, 1930. From Chem. Abst., **24**: 2872, June 10, 1930. Possibility of hot-dipping in field for protection of pipes is considered and method of operation described.—*R. E. Thompson.*

Ideal Coating for Pipe. G. WEHRLE. Oil and Gas J., **28**: 51, 138 and 208–10, 1930. From Chem. Abst., **24**: 3102, June 20, 1930. The 7 characteristics of a good pipe coating enumerated by subcommittee of American Gas Association in 1927 are discussed.—*R. E. Thompson.*

Corrosion and the Painting of Steel. HARRY F. PERKINS. Am. Paint J., **14**: 29, 76f, 1930. From Chem. Abst., **24**: 3120, June 20, 1930. Electrolytic theory of corrosion is reviewed. All new steel and iron should be sand blasted before painting. This operation removes scale and dirt and drives out gas and moisture from pores of metal. Corrosion retarders and inhibitors are of value. Aluminum foil has been used with considerable success, but satisfactory adhesives for it have not been developed.—*R. E. Thompson.*

An Experimental Investigation of the Strength of Welds as Affected by Coatings of Rust, Paint, and Oil Upon the Welded Surface. G. F. ROGERS. J. Am. Welding Soc., **9**: 1, 38–40, 1930. From Chem. Abst., **24**: 2975, June 20, 1930.—*R. E. Thompson.*

The Iodine-Deficiency Theory of Goiter. Morphology of the Rat Thyroid on an Iodine-Free Diet. C. ALEXANDER HELLWIG. Endokrinologie, **6**: 161–7, 1930. From Chem. Abst., **24**: 3052, June 20, 1930. It is not possible to produce thyroid hyperplasia by using an iodine poor diet in the goiter region. Lack of iodine is therefore not regarded as principal cause of goiter.—*R. E. Thompson.*

Bacterial Examination of California Water Supplies. C. S. GILLESPIE. Western Construction News, **4**: 20, 538 1929. From Chem. Abst. **24**: 3068. June 20, 1930.—*R. E. Thompson.*

Hygienic Condition of Water Supply During the Cold Period of 1928-9. KRÜSMANN and HAYO BRUNS. Gas- u. Wasserfach, **72**: 1046–50, 1929. From Chem. Abst., **24**: 3068, June 20, 1930. Extremely cold weather in Germany during winter of 1928–9, together with very low precipitation, caused numerous water supply problems. Usual biological removal of phenols ceased and those plants which depended on sand filtration received many complaints of phenolic taste, which was absent at plants using bank filtration. Usual organic filter coating was ineffective. Experimental work was carried out with active charcoal for removing chlorophenol taste from chlorinated water. Care had to be taken to heat concentrated chlorine solutions to avoid chlorine hydrate formation. Fewer typhoid cases were encountered than in other years.—*R. E. Thompson.*

Design of Sedimentation Reservoirs for the Mechanical Purification of Water. S. CHIAUDANO. Ingegnere (Rome), **3**: 470–7, 1929. From Chem. Abst., **24**: 3068, June 20, 1930.—*R. E. Thompson.*

Nomography. OTTO LIESCHE. Chem. Fabrik, 1930, 150. From Chem. Abst., **24**: 3067. June 20, 1930. Nomogram for determining alkalinity of boiler water (Cf. C. A., **24**: 6).—*R. E. Thompson.*

Hard and Soft Drinking Water. W. LOHMANN. Mineralwasser-Fabrikant, **33**: 849–50, 1929; Wasser u. Abwasser **27**: 11. From Chem. Abst., **24**: 3067, June 20, 1930. General discussion with literature review.—*R. E. Thompson.*

Determination of Hardness in Water by Means of Soap Solution. T. VON ESTREICHER. Chem.-Ztg., **53**: 800, 1929. From Chem. Abst., **24**: 3584, July 20, 1930. Method described by BRUHNS (C. A., **23**: 4516) for determining separately the calcium and magnesium hardness of water was originally described by OLSZEWSKI (Abhandl. Krakauer Akad. Wiss., Math.-natur. Kl. **9**: 173, 1881).—*R. E. Thompson.*

Adsorption of Cresol on Activated Carbon. L. PIATTI and O. SPRECKELSEN. Z. angew. Chem., **43**: 308–10, 1930. From Chem. Abst., **24**: 3149. July 10, 1930. Large quantity of steam is required to free adsorbed cresol from activated carbon. For complete removal, only extraction by organic solvents is practical.—*R. E. Thompson.*

Corrosion Tests of Iron and Steel in Distilled, Tap, and Sea Water. KUMAHIKO HASEGAWA and SOJI HORI. J. Eng. Assoc. Manchuria, **7**: 35, 27 pp., 1930; Ryojun Coll. Eng., Pub. No. 1. From Chem. Abst., **24**: 3205, July 10, 1930. Tests were made on 126 specimens, extending over various periods of time, longest being 52 weeks. Corrosion loss was greatest in distilled water and least in tap water. In distilled water, corrodibility of steel increases proportionally to carbon content; in tap and sea water it increases up to 1 percent carbon. Beyond this percentage corrodibility decreases. Corrodibility of cast iron is similar to that of medium-carbon steel. Wrought iron shows greatest resistance.—*R. E. Thompson.*

The Geochemistry of Iodine and Its Circulation in Nature. GULBRAND LUNDE. Chem. Reviews, **6**: 45–61, 1929; cf. C. A., **23**: 1845. From Chem. Abst., **24**: 3200, July 10, 1930. A review.—*R. E. Thompson.*

Iodine in the Waters of the Argentine Republic. A. A. BADO and R. A. TRELLES. Añales assoc. quím. Argentina, **17**: 209–15, 1929. From Chem. Abst., **24**: 3294, July 10, 1930. Quantities of iodine and magnesia, and the Na_2O: (CaO + MgO) ratio are shown for waters of various origins.—*R. E. Thompson.*

Effect of Dry Periods in 1928 and 1929 on the Water Supply of Trier. WAHL. Gas- u. Wasserfach, **73**: 265–8, 1930. From Chem. Abst., **24**: 3295, July 10, 1930. Author discusses effect of dry periods on total volume, chlorine content, total hardness, etc. Graphs are shown for 1929 and for series of years previous.—*R. E. Thompson.*

Purification of Drinking Water by Slow Sand Filtration. HANS DORNEDDEN. Gas- u. Wasserfach, **73**: 289–94, 319–25, 340–2, 1930. From Chem. Abst., **24**: 3296, July 10, 1930. Comprehensive study of slow sand filtration was made with particular attention to effect of grain size. New material, "Vulkanit," having high porosity and consisting of ground lava treated with warm sodium carbonate and hydrochloric acid solutions, gave much higher initial rates of filtration than quartz sand, but much more rapid decrease in rate, because of slime extending further into pores. Organisms in upper part of slime were of usual type found in slow sand filters, but lower part of slime was inorganic in nature and more or less ineffective. With regular flow, somewhat more efficient bacterial removal was attained with Vulkanit; but, with varying flow, it was inferior in this respect to quartz sand. Vulkanit was also quite friable, tending to break up when handled. Somewhat more favorable results were secured with a non-submerged filter, but this required too much supervision and gave low rates because of excessive sliming of upper layers. While large pore-volume gives greater absorption of bacteria, increase in pore size is liable to cause difficulty when demand on filter is suddenly changed. Bacteria absorbed by filter slime are consumed by filter organisms with some oxygen consumption. Ordinarily, this effect is negligible; but, with very slow filtration, oxygen deficiency may develop in filter bed. This study indicates the complex nature of slow sand filtration and it is suggested that coagulation methods of purification are preferable for many surface waters unless specific study is given to each set of conditions and the filter operated very carefully. —*R. E. Thompson.*

Sampling Water for Oxygen Determinations. EDUARD MERKEL. Chem.-Ztg., **54**: 214, 1930. From Chem. Abst., **24**: 3297, July 10, 1930. To avoid bubbling air through water taken for analysis a filling tube of metal, with second tube within it reaching just below stopper, is inserted through cork, and water then run in through outer tube. Air is displaced with minimum contact with sampled water.—*R. E. Thompson.*

Studies on the Dissolved Oxygen Absorption Test. IV. E. A. COOPER and S. D. NICHOLAS. J. Soc. Chem. Ind., **49**: 119–20T, 1930; cf. C. A., **23**: 923. From Chem. Abst., **24**: 3297, July 10, 1930. Variation of temperature and proportion and concentration of sodium molybdate and hydrogen peroxide had no effect in preparation of the catalyst in sodium permolybdate solution which accelerates absorption of oxygen. A 1:5000 solution of sodium molybdate is without effect in oxidation of dextrose by air, but after treatment with hydrogen peroxide the solution markedly accelerates rate of oxidation. Alkali induces oxidation of sugar, but catalytic activity of permolybdate solution is not due to its slight alkalinity, and addition of alkali sometimes inhibits its effect. Oxidation of sugar in alkaline solution is often retarded by catalytic permolybdate solution. Catalytic effect of permolybdate solution in treatment of 0.1 to 2.0 percent solutions of dextrose for 2 weeks was too small for the sugar oxidized to be detected. The catalyst is probably highly unstable and decomposes during catalysis.—*R. E. Thompson.*

Examination of Water After Purification Through a Norite Filter. M. SARDZITO. Mededeel. Dienst Volksgezondheid Mederland.-Indië, **18**: 431–7, 1930. From Chem. Abst., **24**: 3296, July 10, 1930. Favorable results were obtained.—*R. E. Thompson.*

Sterilization with Chlorine and Some of the Newer Industrial Uses. L. H. ENSLOW. Can. Chem. Met., **14**: 108–9, 1930. From Chem. Abst., **24**: 3297, July 10, 1930. Applications of chlorine in industry are described with particular emphasis on water purification.—*R. E. Thompson.*

Sterilizing Water. RUDOLF ADLER. Fr. 677, 671, July 1, 1929. From Chem. Abst., **24**: 3306, July 10, 1930. In treatment of water with chlorine and passing water over carbon to remove chlorine, the carbon used is treated from time to time with oxidizing agents, alkalies, acids, or alkaline earth salts, which, destroy, dissolve, or precipitate, substances which gradually form on surface of carbon. Cf. C. A., **23**: 4985.—*R. E. Thompson.*

Methods of Determining Hardness of Water. E. F. TEBENIKHIN. J. Chem. Ind. (Russia), **6**: 222–36, 1929. From Chem. Abst., **24**: 3299, July 10, 1930. Investigation was made of all known volumetric methods of hardness determination; their accuracy was tested with specially prepared solutions, natural waters, and softened boiler waters. Tabulation is given of results of 347 tests. CLARKE's method, standardizing the soap solution against barium chloride, gives results which are too low for calcium salts and too high for magnesium salts. To obtain constant foam a considerable lowering of surface tension of salt solutions is required, but it is not always sufficient. In case of moderately hard and hard waters, this method gives lower results than other methods; but if these waters are preliminarily diluted to from 3 to 5° hardness (54 to 90 p.p.m.), the errors are insignificant. In this way method may successfully be used in technology of water purification for control of corrected and boiler waters. Method of WARTHA-PFEIFER (Z. angew. Chem., 198, 1902) gives sufficiently exact results on hard and moderately hard waters, but too low results

on soft waters, particularly those below 3° hardness (54 p.p.m.). C. BLACHER's method is considerably simpler than others and gives very satisfactory results for moderately hard and hard waters, but it gives too high results for very soft corrected and boiler waters. Pure palmitic acid can best be obtained by extraction from Japan wax. The potassium salt, from which solution is prepared, is obtained by neutralizing the acid with potassium hydroxide in glycerol solution.—*R. E. Thompson.*

Industrial Water and Its Relation to the Phormium Industry. P. W. AITKEN. New Zealand J. Sci. Tech., 11: 335–8, 1930. From Chem. Abst., 24: 3298, July 10, 1930. Calcium bicarbonate reacts with tannin in *Phormium tenax*, producing brown coloration. Fiber washed with hard water has inferior color due to this action. Iron salts form greenish blue coloration with the tannin. This is very undesirable in flax-milling water. Analyses and notes are given for 9 water supplies used for *Phormium* washing.—*R. E. Thompson.*

Plans for Chemical Purification of Feed Water Along State Railroad Lines. A. MICHELUCCI. Rivista tec. ferrovie ital., 36: 1, 1–25, 1929. From Chem. Abst., 24: 3299, July 10, 1930. Descriptive notes on number of small lime-soda feed water treatment plants. Organization of feed water treatment service, with special reference to construction and maintenance practice is discussed. Data proving economy of feed water treatment and data on operation costs are given.—*R. E. Thompson.*

Sodium Aluminate Not a Colloid. J. A. HOLMES. Power, 71: 222–3, 1930. From Chem. Abst., 24: 3299, July 10, 1930. Sodium aluminate, which is molecularly dispersed, is useful in reducing silicate content of boiler feed water. Cf. C. A., 24: 1170.—*R. E. Thompson.*

Sanitary Control of Pools in New York City. JOHN E. DOWD. Munic. Sanitation, 1: 216–7, 1930. From Chem. Abst., 24: 3303, July 10, 1930. Samples, taken periodically without notice to operators, were analyzed according to Standard Methods with addition of bacteriological counts on blood agar. Findings are reported with respect to chlorine dosage, maximum use of pool, and relation of total count and *B. coli* content to presence of hemolytic colonies on blood agar.—*R. E. Thompson.*

New Metallo-Chlorination Process for Sterilizing Swimming Pools. WO. OLSZEWSKI. Pharm. Zentralhalle, 71: 161–2, 1930. From Chem. Abst., 24: 3303, July 10, 1930. Alleged improvement of KRAUSE method (chlorine-silver) for rendering swimming pools germ- and fungus-free consists in partial substitution of copper for silver, treatment being just as effective and cheaper.—*R. E. Thompson.*

Bacillus Coli Surveys, Los Angeles Ocean Outfall. W. T. KNOWLTON Calif. Sewage Works J., 2: 150–2, 1929. From Chem. Abst., 24: 3305, July 10 1930. Short paper showing importance of routine surveys for protection of bathing beaches.—*R. E. Thompson.*

Phenol Recovery, By-Product Coke Plant. IV. B. F. HATCH. Blast Furnace Steel Plant, **18**: 618–9, 621, 1930; Cf. C. A., **24**: 1959. From Chem. Abst. **24**: 3304, July 10, 1930. Phenol recovery has done much to minimize chlorophenol tastes in water supplies contaminated by coke plant wastes. Sporadic appearances of phenol under conditions of recovery are most apt to occur during cold months of year, because of several basic causes: (1) biochemical processes of stream self purification are slowed up by low temperature; (2) surface drainage finds its way to streams without purification by soil percolation when ground is covered with snow and ice; (3) accidental leaks and spills constitute important source of phenol contamination. Sufficient phenol frequently arises from other natural sources, such as domestic sewage, drainage from tarred roads, etc., to cause taste in chlorinated water. Ammonia-chlorine process appears to be most promising method of eliminating phenolic tastes. Ammonia in concentration of 0.25 p.p.m., added prior to chlorination, is effective in avoiding taste without impairing sterilization accomplished by 0.2 to 0.5 p.p.m. of chlorine. If phenol concentration reaches 1 p.p.m., 0.5 p.p.m. of ammonia and 0.3 to 0.5 p.p.m. of chlorine are used.—*R. E. Thompson.*

Removal of Phenols from Effluents. L. M. HOROWITZ-WLASSOWA. Gas- u. Wasserfach, **73**: 275–8, 1930. From Chem. Abst., **24**: 3304, July 10, 1930. When phenol solutions are intensively aërated in presence of catalysts such as soil or wood charcoal to sufficient extent, phenols are oxidized to compounds which no longer give bad smelling product with chlorine and which require less chlorine than phenol. Bacterial action does not enter into this phenomenon. Well aërated charcoal or soil filters destroy phenols very rapidly.—*R. E. Thompson.*

Treatment of Milk Products Waste. II. E. F. ELDRIDGE. Mich. Eng. Expt. Sta. Bull. **28**: 3–31, 1930; cf. C. A., **24**: 188. From Chem. Abst., **24**: 3304, July 10, 1930. Data are given on purification effected by sand, gravel, brush, and cinder filters.—*R. E. Thompson.*

Disposal of Effluents from Viscose Rayon Factories. JOHANN EGGERT. Rayon Record, **4**: 8, 417–23, 1930. From Chem. Abst., **24**: 3303, July 10, 1930. Author classifies effluents from different departments and on this basis suggests system making use of: (1) aëration for removal of hydrogen sulfide; (2) suitable mixing of effluents to remove acidity, or alkalinity: (3) filtration to remove cellulose; and (4) treatment with limestone to remove mineral acidity.—*R. E. Thompson.*

Integral Waterproofing Compounds. MAURICE B. LAGAARD. Univ. Minnesota, Eng. Expt. Sta. Bull. **6**: 25 pp., 1927. From Chem. Abst., **24**: 3339, July 10, 1930. Strength and permeability tests were made on number of proprietary waterproofing compounds not identified in paper. In most cases strength was decreased by addition of waterproofer. Effectiveness of compounds, as measured by permeability, varied greatly, some being beneficial and others harmful. Some are beneficial in one mixture and harmful in another.—*R. E. Thompson.*

Iron Oxide Pigments and Rust Prevention. HANS WAGNER. Farben-Ztg., 35: 1151–2, 1204–6, 1930. From Chem. Abst., 24: 3386, July 10, 1930. Single pigment paints prepared with 27 iron oxide pigments and linseed oil were applied to iron panels. After drying 30 days, panels were placed in water for 10 days. Amount of swelling was proportional to percentage of oil in paint. Rusting was classed as below or above film. Conductivity values obtained with JÄGER penetrator were proportional to degree of rust above film and, therefore, to permeability of film. Degree of rusting could not be correlated with such properties as particle size, iron oxide content, oil absorption, etc., but it did occur most with those natural pigments containing alkali, or calcium sulfate, and with synthetic pigments containing residual acid.—*R. E. Thompson.*

New Metal Coatings for Preventing Rusting. H. KRAUSE. Werkzeugmaschine, 33: 249–51, 1929; J. Inst. Metals, 42: 504. From Chem. Abst., 24: 3477, July 20, 1930. Discussion of various methods of preventing rusting or oxidation of metals by coating with other metals, dealing chiefly with electrochemical protective agents.—*R. E. Thompson.*

Modern Trend in Fighting Corrosion. T. HENRY TURNER. Heat Treating and Forging, 15: 860–4, 1929; J. Inst. Metals, 42: 503. From Chem. Abst., 24: 3476, July 20, 1930.—*R. E. Thompson.*

Report on (The Determination of Boron in) Waters, Brime, and Salt. C. H. BADGER. J. Assoc. Official Agr. Chem. 13, 155, 1930. From Chem. Abst. 24, 3458, July 20, 1930. Following method has been used for some time in various laboratories of United States Food, Drug and Insectide Administration. Make sample slightly alkaline with sodium carbonate crystals, if necessary, and adjust to 50 cc. volume in porcelain evaporating dish either by evaporation, or by addition of water; prepare standards containing, respectively, 0.01, 0.10, 0.50, and 1.0 milligram of boric acid in similar evaporating dishes; acidify sample and standards with hydrochloric acid and add 5 cc. in excess; fasten strips of turmeric paper 10 x 0.5 inch to rack so that lower ends dip exactly 0.5 inch into solutions; let stand 4 hours at room temperature in place protected from drafts; and compare characteristic red color developed on strips by sample and standards; make closer estimations by repeating determination with range of standards more nearly equal to content of boric acid. It is difficult to compare less than 0.01 or more than 5.0 milligrams or boric acid by this method. Method is simpler than GOOCH method but practice is required in interpreting results. Collaborative study of method is recommended.—*R. E. Thompson.*

Water and Its Importance in Modern Power Stations. GEORGE HEWSON. Fuel Economist, 4: 184–6, 235–6, 285–6 (1928 & 1929). From Chem. Abst., 24: 3584, July 20, 1930. Troubles caused, particularly in modern high-pressure boilers, by impurities in feed water are carefully considered. Effect of oxygen concentration in water on rate of corrosion and factors regulating oxygen concentration are discussed in detail.—*R. E. Thompson.*

Purification of London's Water. S. WALKER. The Surveyor, 79: 2032, 9, January 2, 1931. This article covers the construction and operation of primary filters for use in connection with the slow sand filters of the Kempton Park division of the London water supply system. A detailed description is given of, (1) the grading of sand and pebbles, (2) the construction of plant and filters, (3) the filtering area and capacity and (4) the operation of the filters, including cleaning and subsequent treatment after the water has passed through the slow sand filters. Prior to the installation of the primary filters the average quantity of water filtered per acre cleaned per annum was 31.4 million gallons. Subsequently the amount has increased to 92.6 million gallons and it is stated that the rate will increase as the slow sand filters become cleaner. This represents a saving of £145,000 in actual capital expenditure. In addition the bacteriological quality of the water has been improved. —*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Ground Water as a Source of Supply: Limitations, Types and Precautions. C. B. BURDICK. Surveyor, 78: 2027, 561, November 28, 1930. A review of an article in which the author draws particular attention to the relation between rainfall and the available capacity of wells; also to the importance of geological conditions. Infiltration galleries are discussed briefly and the case of Des Moines, Iowa, is noted, where all the water is derived by percolation from the bed of the Des Moines River into collecting galleries.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

The Drought and Municipal Water Supply Shortage. W. SCOTT JOHNSON. Missouri Public Health News, 3: 5, 99, January, 1931. A decrease of approximately 25.5 percent below the normal precipitation for the first eleven month period of 1930 has seriously affected the quantity of water available to several Missouri cities. If the drought continues into 1931, public supply sources will be still further depleted and ground water supplies may possibly be affected. As a preparation for such a contingency certain precautions are recommended, including metering of all users to eliminate wasteful flat-rate methods, measuring of quantity of water produced so that losses through leaks may be detected; securing competent engineering advice for increasing supply when shortage appears probable; careful planning and check of available resources by superintendent.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Chlorination of Circulating Water. Reprint of a report by the National Electric Light Association, 1931. Experiments have shown that chlorination of the circulating water for condensers is adaptable to plant operation. Chlorine has a distinct inhibiting effect on the algae growth. It is mostly a preventive measure, however, as it apparently does not clear condensers of slime already formed and in this light should be considered an auxiliary to other cleaning methods. "Results fully justify the idea that intermittent is just as effective as continuous feeding and furthermore it appears that the interval between feedings can be increased still further. (Approximate time of chlorine feeding in these experiments = 8 minutes per hour.) If this is possible it should mean a further reduction in chlorine cost." No evidence exists that

the injection of chlorine in the minute quantities required, has any deleterious effect on the condenser tubes or impeller rotors of the pumps.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Zeolite as a Factor in Municipal Water Softening. R. B. THIEME. Western Construction News, 5: 20, 533, October 25, 1930. This is an instructive article on municipal water softening with special reference to the use of the zeolite process. The following subjects are discussed: (1) three methods of softening; (2) the most economical softening method; (3) comparative costs; (4) pressure vs. gravity softeners; (5) types of installations; (6) cost and performance, "Crystalite" zeolite. There are some sketches of water softening plant layouts and a chart showing performance of a "crystalite" zeolite bed. There are tables showing the following: (1) classification of supply water; (2) reagent costs for softening 10 m.g.d. to 51 p.p.m.; (3) result and cost of lime-zeolite softening applied to the same water shown in table two; (4) reagent costs; (5) estimated cost of the three types of softening plants for 10 m.g.d. of 51 p.p.m. effluent; (6) summary of tables 4 and 5.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Sewage and River Purification Experience. KARL IMHOFF. Surveyor, 79: 2034, 57, January 16, 1931. The Hengstey Lake has been in operation for 2½ years, and has given consistently good clarification of the river water. The construction of the Harkort Lake is nearing completion and will improve conditions at the Wuppervale waterworks. The absence of floods has been a source of trouble to the Rhenish-Westphalian waterworks at Mulheim as the river sludge which comes from above collects in front of the Ruhr dam. In the future, the proposed Boldeney Lake will alleviate this trouble.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Advantages and Disadvantages of the German Type of Sewage Board. K. IMHOFF. Surveyor, 79: 2035, 82, January 23, 1931. Without some central authority to plan waste disposal, numerous separate small purification plants come into existence, and while the individual may do the utmost to solve his problem the final result is a most unsatisfactory confusion. In such instances the creation of a sewage board may prove to be the solution of the problem. The advantages of such a board lie in the single technical staff to which all problems may be referred, the broad view possible of the entire river valley as a whole and the saving in the cost of construction and operation of combined works. In the advantages must also be included the value of making an industrial river once again suitable for meeting industrial and municipal water needs, its use for water sports, sun-bathing and the general health of the people, and the advantages to fish and natural life. The disadvantages of such boards lie in the extensive powers delegated to them by special acts and the danger of bureaucracy, the tendency toward standardization to the exclusion of all other ideas and developments, mistrust on the part of the public during its early existence, the danger of overorganization and the inability to reduce its staff on completion of its work.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

The Natural Purification Capacities of Streams. H. W. STREETER. Sewage Works Jour., **2**: 1, 131, January, 1930. In a flowing stream the time of flow between two fixed points may vary and the degree of purification will vary correspondingly. The density of the bacterial population reaches a maximum usually from 10 to 15 hours after pollution enters the stream. It is not clear whether this is due entirely to increase in bacteria or partially to a progressive disintegration of particles containing them. Sufficient work has been done on streams to express the probable oxygen balance in mathematical formula. The effect of reaëration and the relatively slow oxidation of organic matter are emphasized as factors in maintaining dissolved oxygen in the stream.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Automatically Controlled Acid Effluents. H. K. RICHARDSON. Reprint Chemical and Metallurigal Eng., **36**: 5, May, 1930. Through an ingenious arrangement, equipment has been installed in the Bloomfield plant of the Westinghouse Lamp Company for automatically neutralizing acid wastes. Besides economies amounting to approximately $5,000 annually, continuous record insuring no wastes acid to methyl orange being emptied into the Passaic River has resulted. An electrolytic conductivity recorder records the strength of acid leaving the dip-room wash tanks and rings a bell when the strength reaches a certain point. Contacts operate a motor-controlled valve governing the addition of water to the raw acid-wash water. A hydrogen ion recorder records the pH of the effluent leaving the neutralization tanks. Contacts on this instrument control a valve capable of adding soda-ash solution in an emergency. Various details had to be worked out before smooth operation resulted. Diagrams and graphs accompany the article.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

A Sanitary Survey of the River Murray. E. A. HEPBURN. Health Bulletin, Department of Public Health, Melbourne, Australia, **23**: 747, July-September, 1930. This survey, covering the Murray River and tributaries to a distance of 35 miles upstream, started in November, 1929, completed in March, 1930, was for the purpose of limiting future and reducing present contamination. Contamination of the Murray is not as serious as that of some of its tributaries. Contamination from domestic sewage, street drainage, animal pen drainage, slaughterhouse, exposed night soil deposit, and butter factories was found. Proximity of sources of contamination to water supply intakes and bathing beaches were noted.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Report on Nonferrous Metals and Protective Coatings. Bureau of Standards. Jour. of Research, **7**: 3, 585, September, 1931. The starting of the Bureau of Standards Soil Corrosion Investigation in 1922 called attention to soils as possible causes of corrosion and raised questions as to the best methods of preventing the deterioration of pipe lines. Recognizing the close relation between this problem and the investigation already started, the Bureau undertook to determine the corrosion resisting properties of a considerable variety of materials. This report deals with the nonferrous materials used to reduce corrosion losses and includes a few data on rates of corrosion of ferrous ma-

terials in order to show the effectiveness of the nonferrous materials.—*A. W. Blohm.*

Micromax. Leeds and Northrup Company. Catalog 87. Micromax is put forward by its makers as a basic contribution to the advancement of industrial pyrometry. Micrometer sensitivity, automatic standardization and rapid recording are combined with the established accuracy and reliability of the potentiometer circuit. Micromax is, in every detail, a fully automatic potentiometer pyrometer.—*A. W. Blohm.*

Typhoid Fever and Epidemic in a Leper Hosptal. LEE S. HUIZENGA. American Journal of Public Health and the Nation's Health, 21: 1, 50, January, 1931. Out of 200 inmates of the asylum on Taikam Island, South China, at least 60 developed typhoid fever and 52 died. Unquarantined new arrivals at the institution had infected the water and food supplies.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Water Rights Do Not Always Permit Diversion of Streams. LEO T. PARKER. Water Works Eng., 83: 26, 1839, December, 1930. The author interprets the legal rights involving the use of water from streams. He presents quotations from the higher court, decisions on the subjects of riparian rights, and he defines the liability for diversion. Several court decisions are cited which should be of interest to municipalities using water supplies subject to pollution.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Sanitation of Swimming Pools, Wading Pools and Bathing Beaches. HUGH S. CUMMING. American City, 43: 3, 123, September, 1930. The factors affecting the quality of water in bathing beaches and swimming pools from a public health standpoint are brought out. There is a discussion of the various methods of disinfecting swimming pool water and of recent progress along this line.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Paying for a New Pumping Station Out of Savings. ELLIS IRVING CRONK. Public Works, 62: 7, 19–20, 1931. New electrical water pumping station for New Brunswick, N. J., which is described, has pumping capacity of 16 m.g. per day, will permit annual savings in pumping costs of $20,000 per year, and will return its cost to the city in three years.—*C. C. Ruchhoft.*

Bacteria and the Water Supply. Anon. Public Works, 62: 9, 34, 1931. A general non-technical review is given.—*C. C. Ruchhoft.*

Water Distribution by the Two-Main System. J. EDWARD SCHIPPER. Public Works, 62: 9, 31–2, 1931. Advantages of two-main system are pointed out. In first cost, it may, in general, be at a disadvantage; but with roads of 55 feet, or more, cost also may be in its favor. When cost of maintenance, service installation, upkeep of dead service lines, and losses resulting from traffic delays and inconveniences are added together, the slight differences in favor of single-main system due to lower first cost on narrow roads disappear.—*C. C. Ruchhoft.*

Corrosion Reduction with Lime Treatment. EDWARD S. HOPKINS. Water Works & Sewerage, **72**: 191–2, 1931. Absorption of CO_2 by use of lime is practical, cheap, and easily controlled. This procedure assures the elimination of "red water" troubles. Excessive amounts of lime will tend to clog smaller pipes and must be avoided by careful supervision, or automatic regulation, so as adequately to protect service pipe from deposit.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Water Purification with Ultra-Violet Radiation. J. F. SPRINGER. Public Works. **62**: 10, 39, 1931 and 11, 65, 1931. For ultra-violet treatment, water must first be clarified. Process itself does not either clarify, or decolorize; but it kills germs. It is superior to chlorination in that no odors, or tastes, are produced. Efficiency of the germicidal action depends upon time of exposure. It is necessary to have the water pass through four sterilizing units. Direct current must be used. Experimental data and cost are given.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Water Purification at Cameron, Missouri. BENNETT B. SMITH. Public Works, **62**: 11, 43, 1931. Water is treated by chlorination and filtration. An unusual aërator is used.—*C. C. Ruchhoft.*

City Wells Hit by Drought. A. ELLIOTT KIMBERLY. Public Works, **62**: 8, 55, 1931. Water level in the wells at Urbana, Ohio, has fallen continuously from March 1930 to June 1931.—*C. C. Ruchhoft.*

The Why and How of Water Purification. Anon. Public Works, **62**: 9, 15–16, 1931. Brief summary of present practices and of fundamental theories upon which they are based. Applications in designing and operating water purification plants are given.—*C. C. Ruchhoft.*

How a Modern Supply Saved Lake Odessa. E. G. GARLINGER. Public Works, **62**: 9, 28, 1931. Construction of 75,000-gallon elevated steel water tank for emergency uses in 1928 saved town from a very disastrous fire in 1930. —*C. C. Ruchhoft (Courtesy Chem. Abst.).*

The Brownsville Water Purification Plant. HENRY E. ELROD. Public Works, **62**: 8, 19–20, 1931. New 4-m.g.d. rapid sand filter plant for treating Rio Grande River water is described. Features of plant include an aërator, mixer, and primary settling tank equipped for continuous removal of sludge.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Court Decision Relating to Public Health. Public Health Reports, **46**: 51, December 18, 1931. 3064. **Liability of Municipality for Damage Resulting from Sewage Disposal into a Stream Flowing through Plaintiff's Land.** Georgia Court of Appeals; City of Barnesville *vs.* PARHAM, 160 S. E. 879; decided October 3, 1931.—*R. E. Noble.*

The Chlorination of Ballast Water on Great Lakes Vessels. G. H. FERGUSON. Public Health Reports, **47**: 5, 256, January 29, 1932. Ballast water

tanks are usually filthy and contain accumulated rust and sediment. When foul harbor water has been added to them, pollution therewith of otherwise uncontaminated water near municipal intakes is quite possible. Chlorination by chlorinator using 2 percent sodium hypochlorite at time of discharge offers too short a contact period. Higher chlorine concentration with period of retention in ship tank might corrode the ship plate. Hence, construction of a separate tank would be required. While effective, cost might be prohibitive. More economical method would be to chlorinate influent ballast water since effective contact period would thus be obtained. Serious objection, however, is the damaging corrosive effect of chlorine on steel plate.—*R. E. Noble.*

Filtration of Water Supplies. HAROLD C. CHANDLER. Connecticut Health Bulletin, **43**: 11, 402, November, 1929. Author concludes that as means of securing safe, clear, colorless, and tasteless supply of water, chemical treatment and filtration should be employed. Vital statistics show conclusively that typhoid fever death-rate has been reduced to a minimum as direct result of water purification processes. In near future it will be required by law that all public water supplies shall be filtered, with exception of certain ground waters.—*R. E. Noble.*

The Sanitary Significance of the Presence of Ps. Pyocyanea in Water Supplies. G. MACKEY. Indian M. Gaz., 1931, **66**: 248–50. From Bull. of Hygiene, **6**: 6, 703, September, 1931. Presence, or absence, of *Ps. pyocyanea* in water samples tested in laboratory in Rangoon has been correlated with results obtained in ordinary bacteriological tests. Samples were from tube wells, shallow wells, lakes, and pipes. During one year *Ps. pyocyanea* was isolated from thirteen samples, and in each case *B. coli* was also present. Presence of *Ps. pyocyanea* may well be interpreted as danger signal, since it is frequently found after twenty-four hours on agar plates.—*Arthur P. Miller.*

International Register of Spas and Medicinal Waters. Compiled by the Standard Measurements Committee of the International Society of Medical Hydrology, 55 Wellington Road, London, N. W. 8. (Approved by the Council March 21st, 1931.) 1st. Edition. London. From Bulletin of Hygiene, **6**: 9, 729, September, 1931. This section contains directions as to classification of waters on chemical, physical, and medicinal characters, and modes of expressing them. Information on spas will be given under the headings of climate, geology, and nature of surroundings, which will be a much more serviceable method of presenting data than the present one, which involves reading pages of diffuse statements of reports.—*Arthur P. Miller.*

Second Report of the Scottish Advisory Committee on Rivers Pollution. River Esk (Midlothian). W. E. WHYTE. Department of Health for Scotland. 1931. Edinburgh. From Bulletin of Hygiene, **6**: 10, 766, October, 1931. Description of pollution of River Esk, contributed largely by trade waste from paper mills. Esparto grass, used in large quantities, is first boiled in caustic soda, then twice washed. Chloride of lime is used for bleaching. From this it is apparent that wastes are of intensely polluting nature. Collieries also

add to load carried by river. Sewage pollution is less important. Complete purification will be a difficult problem, because of volume of water abstracted from river for trade purposes.—*Arthur P. Miller.*

The Use of Eosin and Fluorescein in the Sterilization of Water Supplies by Ultra-Violet Light. H. WELCH and R. G. PERKINS. J. Preventive Med., 1931, 5: 173–9. From Bulletin of Hygiene, 6: 10, 766, October, 1931. Suspensions of *B. coli* to which had been added varying amounts of eosin, or of fluorescein, were exposed to ultra-violet light. Suspensions containing between 1 in 10,000 and 1 in 1,000,000 parts of eosin were sterilized in four seconds when exposed to the particular carbon light at a distance of 25 cm. Greater concentrations of eosin were not so effective, due probably to inability of the light to penetrate the more highly colored solutions. This method may have an application in sterilizing such liquids as orange and grapefruit juices.—*Arthur P. Miller.*

The Advantages of the Ammonia-Chlorine Treatment of Water. J. F. T. BERLINER and ARTHUR E. HOWE. The American City, 45: 4, 102–104, October, 1931. When dilute solution of ammonia is treated with chlorine, chloramines are formed. Under conditions usually prevailing in treatment of water supplies, only monochloramine and dichloramine are encountered. Chlorine gas has phenol coefficient of 2.18 when applied alone; but, when ammonia previously introduced, of 6.36. The combination, therefore, is more bactericidal than chlorine alone. Ammonia-chlorine treatment is also effective against algae and slime growths. In studying relative action of chlorine and chloramine on Cyclops, it was observed that while chlorine alone in concentrations of 8.0 p.p.m. was not fatal in two hours, yet, when combined as chloramine, concentration of 2.9 p.p.m. was lethal in 75 minutes. Chloramine is especially effective against tastes and odors of medicinal, iodoform, chlorinous, or phenolic character. Application of ammonia is similar to that of chlorine, except that ammoniator is used instead of a chlorinator. Average ratio of ammonia to chlorine is about 2:3. The *o*-tolidine test for residual chlorine remains applicable in ammonia-chlorine treatment, but reaction is slower than when chlorine alone is used; at least twenty minutes should be allowed before comparison with standards.—*Arthur P. Miller.*

Effect of the 1930 Drought on 1931 Water Supplies. Prepared from Official Sources and Annual Reports. The American City, 45: 4, 105–106, October, 1931. Reviews information obtained from official sources in Ohio, Kentucky, and a few other states affected by 1930 drought. Conditions in thirteen villages and cities in southern Ohio which did not obtain their water from Ohio River are described in part. Survey of underground water in Ohio in 1931 showed that water in deep wells was either stationary, or slowly receding. This indicated need for normal, or greater, rainfall throughout spring, or summer, if late summer shortage were to be avoided. In Louisville, Kentucky, district, during seven-month period from April to October, rainfall deficiency was 65 percent. Conditions in Maryland, West Virginia, and North Carolina are also briefly described.—*Arthur P. Miller.*

Water is not Free: But, by Completing a Public Water System, a Small Maryland Town Reduced Taxes. T. W. HACKER. The American City. 45: 4, 109–110, October, 1931. Since about 1900, people of Williamsport, Maryland, have been agitating question of new public water supply. In 1922, Maryland legislature authorized bond issue of $100,000 and, after suitable investigation of all suitable sources of supply, it was decided to purchase water from Hagerstown, Maryland, then contemplating development of its Potomac River supply with a new treatment plant. Williamsport installed its own distribution system, metering it 100 percent. Price paid Hagerstown is 13 cents per thousand gallons. Fire insurance rates have been reduced 45 to 50 percent and, in addition, town has been able to reduce tax rate from 45 to 40 cents per $100.00.—*Arthur P. Miller.*

The Acidity of Several Pennsylvania Streams During Low Water. R. D. LEITCH. Department of Commerce, U. S. Bureau of Mines, Reports of Investigations, 3119, September, 1931. Included among Bureau of Mines studies of effects of coal mine drainage on stream pollution in Pennsylvania, is study of seasonal variations in acidity and volume of several streams. Acidity of these streams had been followed during two or three years prior to 1930, and results representing normal low water conditions were known. Summer of 1930 was unusually dry and represented extreme low water conditions. Report gives results obtained during these extreme low water conditions and compares them with those obtained under normal low water conditions. Tables are given showing acidity of samples from the five creeks studied. In summary it is brought out that two streams showed practically no change in acidity due to decrease in flow; that two others showed increased acidity, one of several hundred percent; and that remaining one showed decrease in acidity, due, however, to observed decrease in amount of drainage entering it. Author feels that there has been no conclusive evidence to support the idea that extreme low water stages always result in greatly increased acidity.—*Arthur P. Miller.*

Guarding Citizens Against Injury. LEO T. PARKER. Water Works Eng., 85: 1, 21 January 13, 1932. In city which operates its own municipal water works system, certain water meter box is maintained in center of paved sidewalk: top of box lies flush with surface of sidewalk and has been so situated for six years, or more. Pedestrian stepped upon the lid: her foot and leg went down in the meter box and she sued city for damages; city was held not liable. A well established law prohibits municipalities from permitting private individuals to make permanent use of any portion of a street for private purposes; and irrespective whether, or not, city grants to property owner right to obstruct a street, or highway, either city, or property owner, may be liable in damages from negligence in maintaining the street in a safe condition. Cites case of a woman being injured by stumbling on projecting hydrant and being awarded damages. The general law always holds that injured person should prove negligence. Writer cites case of boy ten years old, who fell into municipal pond and was drowned; courts held city not liable. Courts hold that municipality can dig ditches on streets; but they must warn the public: if a

person knows of existence of ditch and then becomes injured thereby, city is not liable. Author cites several cases where courts have decided that city is not required to fence water reservoirs, or other bodies of water used in connection with waterworks.—*Lewis V. Carpenter.*

Ancient Water Supplies. JAMES W. ARMSTRONG. Water Works Eng., 85: 1, 18, January 13, 1932. Author gives important historical developments of ancient water systems in well illustrated article.—*Lewis V. Carpenter.*

Use of the Floc Detector to Determine Filter Runs. E. E. WOLFE. Water Works Eng., 85: 1, 40, January 13, 1932. It is often decidedly detrimental to condition of sand bed to attempt to operate filter until it reaches normal maximum loss of head, as mud may penetrate so deeply and so enmesh sand grains, that even 20-minute wash may fail to clarify bed. Floc detector is recommended for regulating time of wash. Presence of flocculated matter and turbidity indicates that sand needs attention, or that applied water is not in its best state. Detailed drawing of floc detector is supplied. Amount of floc, measured in terms of turbidity, never exceeds 0.1 p.p.m. Amount of floc insufficient to produce a fine turbidity of 0.01 p.p.m. is easily detected in flask. Author describes use of this detector at Hannibal, Mo., plant.—*Lewis V. Carpenter.*

Water Supply Contracts. LEO T. PARKER. Water Works Eng., 85: 3, 139, February 10, 1932. A common legal question is whether municipality which extends corporation limits to include new subdivision is obligated to pay cost incurred for installation of water mains. Courts have held the municipality liable. Courts have upheld regulations of water utilities to charge for extensions when said charges are stipulated in rules and regulations of company. Another well established point of law is that consumer who pays excess water rents may recover the same, provided that excess payment was made either in ignorance of state, or city, laws, or under duress. It is also well established law that public service company may make and enforce a reasonable rule to refuse service if, after notice, a bill remains unpaid. However, company is liable in damages, if bill rendered is unjust and erroneous. Various higher courts have held that property owner cannot recover damages although his property is destroyed by fire as result of failure of water company to supply sufficient water. It is well settled, that, under the common law and also under various state statutes, any municipal contract is unenforceable where it is shown that one of contracting parties is a public official and financially interested in performance of contract.—*Lewis V. Carpenter.*

Improvements from Revenue. ROBERT E. MCDONNELL. Water Works Eng., 85: 3, 134, February 10, 1932. Kansas City, Kan., took over its water works in 1909. Typhoid death rate, which was then 42.4 per 100,000, has been reduced to 1.8 in 1930. Original cost of plant was $1,000,000 and present assets are reckoned to exceed $7,000,0000. With present earnings maintained and provided no further bond issues are voted, entire debt will be wiped out by 1950. Town also owns its electric plant and both utilities are operated by

same manager. Both plants have been materially expanded out of earnings.—*Lewis V. Carpenter.*

Limitations of Motors for Pumps. DUGALD C. JACKSON. Water Works Eng., 85: 2, 83, January 27, 1932. For alternating current, choice is limited to synchronous and induction motors when 3-phase power is to be used. Squirrel-cage induction motors are particularly advantageous where it is not possible to have a trained operator on hand at all times. They can also be used in dirty locations, or, there being no uninsulated conductors and no danger, therefore, of shock, in places where people are constantly passing: high voltages, too, can be used without danger. Motor should be selected for the load and, if that is variable, motor with flat characteristic curve should be installed. Variation of load changes power factor as well as efficiency, and necessitates particularly careful consideration in selection of motor. For economy, an induction motor should not operate below 75 percent load; if load drops to 50 percent, a second motor is required.—*Lewis V. Carpenter.*

Water Softening Plant at Quincy, Ill. W. R. GELSTON. Water Works Eng., 85: 2, 80, January 27, 1932. Hardness varies from 100 to 230 p.p.m. When, during season of 1930, improvements to plant were proposed in order to provide employment for the needy, engineer's report showed that softening would be feasible. New equipment was accordingly added to existing filter plant as follows: two agitation basins, 17 x 28 feet in area by 18 feet deep, equipped with motor driven paddles; Dorr clarifier, 85 feet in diameter and 16 feet deep; recarbonation basin; two-story chemical house; and coke storage bin. Recarbonation equipment consists of Scotch marine type boiler in which coke is burned; scrubber and dryer; air compressor; and gas flow meter. Enlarged plant is now arranged so that water entering at same place as formerly is dosed with lime and, after clarification, the soft water goes through recarbonation chamber. It then passes to a second sedimentation basin and then through the filters. When operating at six-million-gallon rate, there is settling period of 1½ hours, 30 minutes of agitation, 2½ hours in clarifier, 30 minutes recarbonation, and final sedimentation of three hours before filtration. Basins are covered, which necessitated special Dorr equipment.—*Lewis V. Carpenter.*

Iron in the Ground Water Supplies of Massachusetts. C. I. STERLING, Jr., and J. B. BELKNAP. Boston Soc. Civil Engs., 19: 1–20, January, 1932. Eighty-nine municipalities in Massachusetts obtain their supply from ground water and 21, from a combination of surface and ground water sources. City of Lowell is supplied with 6,000,000 gallons daily from wells. Glacial deposits are the most suitable sources of supply. Deterioration of ground water supplies is not uncommon. Easterly and northeasterly sections of state experience greatest trouble with iron in water supplies. Seven municipalities have deferrization plants. Aëration, coke filtration, and sedimentation are used at four plants. Where sources of supply are located in swampy areas iron generally occurs. Most common cause for increase in iron content is excessive pumping. Objectionable concentrations of iron may be abated by (1) in-

stalling additional wells on same site to reduce draft of each well, (2) cleaning of wells, because each clogged well will increase draft on the other wells, (3) combining new source with original source to result in smaller amount of iron in mixed water, or (4) installing suitable deferrization plant. Increase in iron content may be due to 1930 draught.—*John F. Pierce.*

Water Supply in 1931. Anon. The Engineer, 153: 3965, 46–47, January 8, 1932, and 3966, 67–68, January 15, 1932. In Great Britain, Scar House reservoir for Bradford is practically completed; ten masonry arches of 30-foot span over spillway to carry road across dam are complete and concrete-lined tunnel, 1852 yards long, nearly so. Shrewsbury adopted proposal to supply town and district from River Severn; Hull increased supply by 10 million gallons (Imp.) per day; Preston has opened Alston reservoir No. 1 (capacity 259 million gallons); and at Halifax new filtration plant has been started. Haweswater scheme of Manchester has been suspended temporarily, except Mardale tunnel, owing to financial outlook and reduced trade demands. French government has declared that it is work of public utility to bring million cubic meters water from Loire valley to Paris; in existing Paris supply, unfiltered water used for town cleaning is to be sterilized with chlorine. Supply to Singapore from Johore will be opened early this year. Shanghai recently increased supply by installing further river intake and Wuching has new water scheme. Proposal has been put forward for new water supply to Moose Jaw, Saskatchewan; Montreal has decided to increase power of waterworks pumping plant; Vancouver is to drive tunnel 3200 feet long to convey water beneath sea to Capitans Creek; and large covered reservoir is to be constructed on Plains of Abraham for Quebec.—*W. G. Carey.*

Water Pollution Research Board (England). Anon. The Engineer, 153: 3967, 108, January 22, 1932. Annual report to June 1931 states that there is zone of water in river Tees where plant and animal life are absent owing to effluents containing phenols, naphthalene, and cyanides, with resultant low concentration of dissolved oxygen. Suggestions for reducing pollution from beet sugar works have been adopted, costs of which are counterbalanced by economies; where discharges unavoidable, 90 percent purification is obtained by biological oxidation on filters. In water softening section, it is stated that sea water can be used to regenerate base exchange materials, and that traces of lead, zinc, copper, or tin, are removed from water by base exchange materials.—*W. G. Carey.*

Metropolitan Water Board (England). Anon. The Engineer, 153: 3965, 47, January 8, 1932. Description of principal works carried out in 1931 at some 15 of Board's stations, including steam-driven centrifugal pump at Kempton to raise 16 million gallons (Imp.) raw water per day to primary filter, remodelling of pumping stations, and improvement of supply to Kent district.—*W. G. Carey.*

The Sterilization of Water by Katadyn Silver. E. V. Suckling. Water and Water Engineering, 33: 397, 625–628, December 21, 1931 and 399, 15–18, Jan-

uary 20, 1932. Following an historical summary, author deals with silver as a poison and with its absorption by, and elimination from, human body and states that Katadynized water can have no deleterious effect on account of its silver content. It was found that living bacteria in Katadynized water could often be detected by liquid media when none were found on solid media; experiments were therefore carried out with *B. coli* and other bacteria using liquid media. Katadyn silver has marked bactericidal power, greatly in excess of that exercised by ordinary forms of metals, and as an algicide it is superior to chlorine. It is superior to chlorine in respect of absence of odour and taste production. Sterilization by Katadyn silver is still too slow; cost is much higher than that of chlorination; and process is susceptible to interference by temperature, turbidity, sulphides, chlorides, iron, and organic matter. As regards public water supplies, process is applicable only to few and carefully selected cases, but it may meet long felt want for sterilizing small supplies, e.g. in country houses.—*W. G. Carey.*

The Evaporation of Reservoirs. Ingenieria y Construccion, 344–345, September, 1931. From Water and Water Engineering, 33: 398, 644, December 21, 1931. Figures for water evaporated from reservoirs as given by WILD balance, or by PICHE atmometer, cannot a priori be taken as those of nature. Comparisons show, however, that results are very approximately the same as those of observations made directly in large masses of water. Direct measurement of evaporation in a reservoir cannot be made by simply gauging intake and outflow without knowing extent of seepage. Empirical constants which various formulae contain to take natural conditions into account, e.g. wind, often render them inapplicable. Principal formulae are criticized; it is proposed to utilize theory of STEFAN for diffusion of vapour and modern studies on the vortex theory for the lower strata of atmosphere.—*W. G. Carey.*

NEW BOOKS

Annual Report of the Bureau of Sanitary Engineering of the Maryland State Department of Health, Year 1931. ABEL WOLMAN. 20 pp. Extensive activities of Bureau during 1931 are reviewed. Difficulties due to drought still continue and number of communities have had to extend their water supply resources. Despite unfavorable conditions, however, typhoid fever death rate declined from 6.2 per 100,000 in 1930 to 5.4 in 1931. Incidence of this disease attributable to water supplies was practically nil. Weekly operating reports are now received from practically all water works in the state. Study of internal corrosion of distributing mains and services was continued and extended during year. In general, corrosion was found to vary inversely with degree of saturation of calcium carbonate in water in question. Dead ends in distribution systems and use of dissimilar metals in plumbing and services were found to be active sources of corrosion, even where corrective treatment had successfully protected larger mains. Increase in manganese content of many ground water supplies has been noted recently. At new Annapolis plant, chlorinated copperas is being employed as coagulant, alum having been found ineffective for removing iron and manganese. Similarly, in Baltimore

iron and lime have to be substituted for alum for from 1 to 12 weeks each fall, when manganese content frequently exceeds 0.5 p.p.m. In continuation of efforts to combat excessive algae growths in Back River, effluent of Baltimore sewage plant, which is discharged therein, is being treated by lime-chlorine process. Treatment plant consists of screens, settling basins, trickling filters, and final settling basins; flow averages 60 million gallons per day. Chlorine is discharged into pipe-line carrying lime suspension at ratio of about 1 to 1.25. Maintenance of excess of lime is secured by control tests with phenolphthalein; sufficient chlorine is applied to maintain residual of 0.5 p.p.m. Lime and chlorine requirements have averaged 3750 and 3000 pounds per day, respectively. Algae growths in river have been considerably reduced; but whether lime-chlorine treatment has been significant factor is as yet undetermined. Effluent has also been experimentally treated with chlorine and metallic copper, a process developed by ORNSTEIN and KROKE (Gesund. Ing. 1930, 53, 153). Sufficient observations have not been made, however, to warrant definite conclusions. Activities in connection with industrial wastes during 1931 were largely confined to group of industries on Upper Potomac River, which was formally organized as "The Upper Potomac River Board." As result of modifications in operating procedures and waste treatment methods employed, valuable by-products have been developed and marked improvement effected in condition of river, despite low flows incident to drought. By an act of Legislature, commission was created to study and report in 1933 on water resources of state.—*R. E. Thompson.*

Vom Wasser. Ein Jahrbuch für Wasserchemie und Wasserreinigungstechnik. IV. Band: 1930. 194 pp. Herausgegeben von der Fachgrappe für Wasserchemie des Vereins deutscher Chemiker. **Ueber den heutigen Stand der Trinkwasserentsäuerung. The Present Status of Acid Removal from Drinking Water.** J. TILLMANS. 13–44. Water containing carbon dioxide may attack either concrete or iron. In absence of dissolved oxygen, dissolved iron remains in solution. In presence of air, dissolved iron is oxidized and rust forms. At pH 7.5 to 7.6, practically no iron is dissolved within 24 hours. Water containing non-aggressive carbon dioxide soon deposits on iron protective coating of iron oxide and calcium carbonate. Oldest method for removal of carbon dioxide is filtration through granular marble, by which aggressive carbon dioxide was converted to calcium bicarbonate. Treatment is automatic and not affected by variations in quantity of water, nor by those in its quality excepting that it is effective only with soft waters. Carbon dioxide may also be removed with lime water. With excess of lime, all carbon dioxide is removed and formation of protective calcium carbonate coating is hastened. Dosage of lime must be accurately controlled in order to obtain satisfactory results. A third method of removing carbon dioxide is by spraying the water into the air; this method is recommended for all hard waters containing aggressive carbon dioxide, but may not be sufficient for soft waters; the treatment is automatic and reduces carbon dioxide from 5 to 7 p.p.m. **Die Entsäuerungsanlage der Frankfurter Wasserwerke im Hochbehälter an der Sachsenhäuser Warte (The Acid Removal Plant of the Frankfurt Water Works).** VIESOHN. 44–50. The city water, although originally containing no iron, dissolved con-

siderable quantities from the pipes because of the high carbon dioxide content. In 1908, first marble filter in Germany was built to remove the carbon dioxide. Water is first filtered downward through sand filter about 3745 square feet in area, to remove turbidity, and then upward through marble filter about 7490 square feet in area and about 2.6 feet deep to remove carbon dioxide. Daily flow has increased from about 7,392,000 to 11,088,000 gallons since 1908. Free carbon dioxide is reduced from about 30 to 3 p.p.m. and pH is increased from 5.8 to 7.0. The total hardness was increased from 1.75° [31 p.p.m.] to 5.25° [94 p.p.m.]. This method should only be used for waters not harder than 5 to 6° [90 to 107 p.p.m.] The marble should be about 0.07 to 0.39 inch in size. New marble is added annually to replace that lost by solution. It is 95 per cent soluble, and about 154 pounds of it are needed for 264,000 gallons of water. The filter is repacked about every eight years, the old material being washed and sorted. **Das Grundwasser im Wandel der Zeiten. (Groundwater During the Course of Time).** G. THIEM. 52–64. Man's ideas regarding comparative merits of ground and surface water as sources of supply have changed from time to time. One main reason that ground water has not been used more extensively is popular notion that its quantity is insufficient. Germany has, however, been furnished with ground water streams of great abundance by the glaciers that covered most of the country. Ground water has the advantage of nearly constant temperature, 9° to 10°C. throughout the year. Ordinary surface water is too warm in summer and too cold in winter. Ground water properly so called is practically free from bacteria and, in most cases, its iron and manganese can be removed simply and cheaply. Its carbon dioxide should be removed only if necessary for hygienic or technical reasons. **Vorzüge und Nachteile der Trink- und Brauchwasser-versorgung mit Oberflächenwasser (Advantages and Disadvantages of Surface Water for Domestic and Industrial Use).** H. HAUPT. 64–82. During recent years, many large communities have been forced to use surface supplies because of insufficient ground water. Surface waters are usually comparatively soft and contain no aggressive carbon dioxide, iron, or manganese. They have the disadvantages of variation in temperature with the season, of absence of free carbon dioxide, of higher cost for purification, of greater dependence upon operation and control, of danger of tastes from organisms and from phenol, and of pollution. **Grundwasser oder Oberflächenwasser (Ground Water or Surface Water?).** HAYO BRUNS. 82–106. Source of water is less important than its properties and properties desired depend upon use for which water is destined. For drinking purposes, water of average hardness is desirable; but, for industrial purposes, soft water is necessary. Selection of source of supply becomes more complicated when cost and quantity are considered. During last 30 years, daily per capita consumption has increased from between 15 and 25 gallons to between 40 and 50 gallons. Question of cost is particularly important in industrial centers, where in some cases as much as 90 per cent of city supply is used for industrial purposes. When pollution is great, slow sand filters are recommended; but, for carefully protected reservoirs or large lakes, rapid sand filters are sufficient. Chlorine should be added when plant effluent is temporarily not free from bacteria. Since chlorination is only a make-shift, it is not recommended generally for properly operated filtration plants. The trouble should be located and

eliminated. In the interesting discussion, many leading water chemists took part. **Die Beeinflussung der Säurestufe durch Chlorung des Wassers (The Effect of Chlorination upon the Acidity of Water).** A. MASSINK. 107–116. Chlorination slightly lowers pH values and imparts to poorly buffered waters an aggressive character. This effect depends on composition and properties of the water, on amount of chlorine used, and on dechlorination practised. However, the dissociation, or dehydration, of H_2CO_3 to CO_2 and water takes place about 2000 times as fast as the reverse reaction of hydration of CO_2 to H_2CO_3, so that the hydrogen-ion concentration is only slowly affected by the acids liberated by chlorination. Except with very soft waters, there is no danger of inducing corrosion by use of chlorine. **Die Beeinflussung der Säurestufe durch Chlorung des Wassers (The Effect of Chlorination upon the Acidity of Water).** L. W. HAASE. 116–120. In practice many reactions in dilute solutions proceed more slowly than would be expected theoretically. The hydrochloric acid formed during chlorination and dechlorination reacts with the calcium carbonate of the water very slowly in dilute solution. Chlorination and dechlorination increase the corrosiveness of soft waters only. It should be determined whether alkalinity present is sufficient to neutralize acid liberated by chlorine and, if not, measures should be taken against corrosion. MASSINK's conclusions only differ on theoretical grounds. **Das Mainwasserwerk mit Schnellfilteranlage der I. G. Farbenindustrie Aktiengesellschaft, Werk Höchst (Rapid Sand Filters of the I. G. Farbenindustrie A. G. at Höchst).** HERMANN ZEH. 120–131. Plant serves to provide water required for industrial purposes, mainly for cooling. Water is drawn from River Main through two siphons into collecting basin about 33 feet deep and 33 feet in diameter. Chlorine is added just before water enters this basin. Dosage varies from 0.5 p.p.m. in winter to about 4.0 p.p.m. in summer. Chlorinated water is pumped to sixteen filters of about 1076 square feet each of filtering surface. Filters are washed with air and water, about 3.5 percent of filtered water being required for washing. Average filter run is about 70 hours. Since water is used for industrial purposes only, plant is controlled by determinations of clarity, that is, of turbidity, and of color as well as by gravimetric determinations of suspended solids. Normally raw water contains about 25 p.p.m. of suspended matter and filtrate, from 2 to 4 p.p.m., a removal of from 85 to 90 percent. **Erfahrungen mit der Laugenbrüchigkeit von Kesselblech in Deutschland (Experience with the Embrittlement of Boiler Steel in Germany).** A. SPLITTGERBER. 131–140. The main results of German investigators partially amplify and partially disprove PARR's theories. In experiments with flange steel, cracks did not develop with the uniformity and speed predicted by PARR. The injurious action of caustic in heat treatment of iron and of certain German steel plate was not observed. Mechanical fatigue of materials of a certain age is very important and certain boiler failures blamed on caustic action may have been due to purely thermal conditions. There is little danger of caustic embrittlement if precautions are taken. Bibliography of 91 titles is included. **Physikochemische Betrachtungen zur Frage des Schäumens von Kesselwasser (Physico-Chemical Considerations Regarding the Question of Foaming of Boiler Water).** FRITZ NIEHAUS. 140–153. Careful supervision of plants preparing water for boiler purposes is necessary. Organic matter should

be kept as low as possible. Surface waters containing organic matter, color, or colloidal material, should be treated chemically and filtered through sand. Use of boiler compounds containing organic matter, or which may be classed as suspensoids, is dangerous. Condensates should be carefully freed from oil. Softening should take place at a high temperature and filtering should be complete, so that no after-precipitation of $CaCO_3$, $MgCO_3$, or $Mg(OH)_2$, occurs. Maximum of 1000 p.p.m. caustic soda is permissible. Only 15 to 20 p.p.m. of phosphate should be present. The total salt content should be kept low by continuous blow-down. The salt content may vary from 3500 to 8000 p.p.m., depending on type of boiler. **Crystalit, ein neuer Zeolith im Dienste der Wasserenthärtung (Crystalite, a New Zeolite for Water Softening).** H. G. BODENBENDER. 154–160. Crystalite is made by mixing solutions of sodium silicate and of either aluminum sulfate, or sodium aluminate, and drying resulting product. Its base exchange value is extraordinarily high, practical exchange coefficient being 1 to 1.1 percent. A smaller filter surface is necessary. Crystalite does twice the work of the old aluminum silicate Permutit and, since it is very hard, only about 3 percent needs to be replaced each year. Neither carbon dioxide, nor dissolved iron, affects its action; although iron should be removed if large amounts are present. Turbidity should also be removed by filtration through sand. Regeneration requires about 25 minutes. The special properties of crystalite are probably due to the fact that it possesses a homogeneous structure. **Streifblicke auf den derzeitigen Stand der Abwasserreinigungstechnik (Survey of Present Practice in the Art of Sewage Disposal).** H. BACH. 160–186. **Gasgewinnung aus Abwasserschlamm (Recovery of Gas from Sewage Sludge).** MAX PRÜSS. 186–192.—*G. P. Edwards, Courtesy F. W. Mohlman.*

Zeolite Water Treatment in a Large Central Heating Plant. ALFRED H. WHITE, J. H. PARKER, EVERETT P. PARTRIDGE, LEO F. COLLINS. Reprint Series No. 1, Department of Engineering Research, University of Michigan, July, 1927. Includes results of preliminary laboratory investigations to determine possibilities of removal of carbon dioxide from zeolite-treated water by means of sulphuric and phosphoric acids; and description of zeolite treatment system thereafter installed in Beacon St. heating plant of Detroit Edison Company. Consideration was given to several methods of treatment before zeolite was finally chosen. Internal treatment with sodium carbonate, tri-sodium phosphate, barium salts, and hot-process lime-and-soda system were rejected after comparison with zeolite system. High caustic alkalinity resulting from zeolite treatment of water high in bicarbonate led to application of sulphuric acid to effluent. The two-fold danger attaching to sulphuric acid, (1) of corrosion, and (2) of sulphate scale deposition should concentration of carbonate fall too low, led to supplementary addition of phosphoric acid, because of its lesser corrosive action and of flocculent nature of calcium phosphate, which does not form a hard scale. Data in tabular and graphical form show results of experiments (1) on effect of acidification and (2) on removal of carbon dioxide. Zeolite softeners at Beacon St. Station are horizontally-set steel cylinders 10 feet in diameter by 25 feet long. Flow is upward, through green-sand zeolite having rated ex-

change value of 3375 grains per cubic foot. Bed is 41 inches thick and operates at 4¼ gallons per minute per square foot of bed area. Water flows through softeners at city pressure, controlled by Venturi type flow controller. After leaving zeolite tanks it receives the acid, and flows into reservoir, from which it is pumped into head tank. From this it flows to de-aërating heater and boiler-feed pumps. Acid-proportioning device feeds dilute acid in exact proportion to amount of water treated. At present 3 percent solution is used and dosage is at rate of about 35 p.p.m. of 100 percent sulphuric acid, which is sufficient to neutralize about 50 percent of sodium bicarbonate present in zeolite effluent and gives pH value of 6.4 to water entering de-aërator and of 8.5 to water entering boiler. Water leaving de-aërator has lost all carbon dioxide set free by acid, while sodium bicarbonate, which was 60.5 p.p.m. after acid treatment, has dropped to 38.5 p.p.m. Inspection of boiler after eight months operation has revealed clean tubes and no serious corrosion.—*R. L. McNamee.*

The Effect of the Disposal of Water Softening Plant Sludge through the Sewage Disposal Plant. E. F. Eldridge. Bulletin No. 34, Michigan Engineering Experiment Station. East Lansing Michigan, January, 1931. Water softening plants using lime, or lime-soda, process produce large quantity of sludge, disposal of which is becoming a difficult problem. Quantity of sludge depends upon degree of treatment and on hardness of original water. For every p.p.m. of temporary hardness removed, 2 p.p.m. of dry $CaCO_3$ is obtained as a sludge. For every 100 p.p.m. of hardness removed per m.g., 1690 pounds of $CaCO_3$ are obtained as sludge. Discharge of such large amounts of material into streams is not satisfactory. Lime-containing sludge can not be dried on beds in the open air. It can be dried only with difficulty on mechanical filters. The $CaCO_3$ obtained is practically useless, as cost of converting it into CaO is in excess of cost of new lime. Knowing the value of acidity control on digestion of sewage solids, it was thought that this might provide a means of disposal of softening plant sludge which would prove advantageous to both water and sewage treatment processes. Major factors to be determined were: (1) effect on the pH of effluent from settling tanks; (2) effect on settling rate; (3) increase in sludge quantity, which will require additional sludge capacity; (4) effect on digestion of the sludge; (5) effect on drying and disposal of sludge after digestion. Laboratory studies were made, using softening plant sludge from Grand Rapids with sewage sludge from Imhoff tank at East Lansing. Samples of mixed sludges were observed for production of total solids and gas. Summary of results:

SAMPLE NUMBER	LIME SLUDGE ADDED	TOTAL SOLIDS	GAS PRODUCED
	percent	*grams*	*cc.*
1		41.6	4815
2		41.7	4924
3	25	41.9	5176
4	25	42.16	5452

SAMPLE NUMBER	LIME SLUDGE ADDED	TOTAL SOLIDS	GAS PRODUCED
	percent	*grams*	*cc.*
5	50	41.7	5724
6	50	41.8	5846
7	75	41.7	5265
8	75	41.8	5376
9	100	41.8	5093
10	100	41.8	5160
11	150	42.5	954
12	150	42.6	900

—*R. L. McNamee.*

The Disposal of Water Softening Plant Sludge at the Sewage Treatment Plant, Grand Rapids, Michigan. E. F. ELDRIDGE. Bulletin No. 40, Michigan Engineering Experiment Station, East Lansing, Michigan, November, 1931. Describes plant scale experiments following laboratory experiments reported upon in Bulletin 34. Grand Rapids water filter plant is operated on excess lime and recarbonation process at average rate of 20 m.g.d., with summer maximum of 36 m.g.d. About 10 tons of lime is used daily in softening, which produces on the dry basis from 18 to 20 tons of lime sludge. Grand Rapids sewage treatment plant consists of screen and grit chambers and Dorr clarifiers from which effluent is temporarily by-passed to river. Sludge is pumped into Dorr digesters heated by the gas produced. Digested sludge is removed to sludge storage or to drying beds. For purpose of test, a pump was set on raft in water softening plant settling basin and lime sludge pumped from bottom of this basin into sewer through which it ultimately reached sewage disposal plant about three miles away. Detailed results of resultant operation of sewage plant digesters are given, from which following conclusions are drawn. (*1*) *Digester Operation.* (*a*) Gas production started much more rapidly with lime than without. (*b*) Rate of gas production and volume of gas produced were greater with lime sludge present. (*c*) Digested combined sludge has much higher solids content than digested normal sewage sludge. (*d*) Decrease in volatile matter content was quite parallel in both cases. (*e*) Only mechanical difficulty encountered was increased load carried by digester mechanism. (*2*) *Influent and Effluent.* (*a*) Lime sludge had very little effect on effluent of primary treatment. The pH, alkalinity, and suspended solids were practically the same as when lime sludge was not present. (*b*) Raw sludge from primaries had much greater solids content and higher pH. (*3*) *Sludge Drying and Fertilizer Value.* (*a*) Sludge drying was accomplished in same manner as with normal sludge and at about same rate. (*b*) Lime sludge acts as diluent on fertilizer value, but has a certain value for correction of soil acidity. (*4*) *Sewerage System.* No trouble was experienced with stoppages. (*5*) *Sludge Capacities.* Larger digester capacity and sludge areas were required, due to increase in solids handled, but not proportional to that increase.—*R. L. McNamee.*

ADVERTISEMENT SECTION

CLASSIFIED INDEX TO ADVERTISEMENTS

Access Shafting:
Alco Products, Inc.
Activated Carbon:
Industrial Chemical Sales Co.
International Filter Co.
Jennison-Wright Co.
Agitators:
Alco Products, Inc.
Air Compressors:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Worthington Pump & Machinery Corp.
Air Lift Pumping Systems:
Worthington Pump & Machinery Corp.
Airlocks:
Alco Products, Inc.
Air Valves:
Darling Valve & Mfg. Co.
Alkalies:
Diamond Alkali Co.
Alum:
General Chemical Co.
Pennsylvania Salt Mfg. Co.
Isaac Winkler & Bro.
Ammonia:
National Ammonia Co., Inc.
Ammonia Receivers:
Alco Products, Inc.
Aqua Tester:
Hellige, Inc.
Base-Exchange Silicate (Zeolite):
International Filter Co.
Zeolite Chemical Co.
Boiler Blowoff Apparatus:
International Filter Co.
Permutit Co.
Brass Goods:
(See also Pipe, Brass)
American Brass Co.
Kennedy Valve Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.
Union Water Meter Co.
Brass Well Screens:
Cook, A. D., Inc.
Edward E. Johnson, Inc.
Calking Tools:
Mueller Co.
Cast Iron Pipe:
(See Pipe)
Castings, Municipal, Street and Sewer:
H. W. Clark Co.
Columbian Iron Works
Caustic Soda:
(See Soda, Caustic)
Cement Lined Pipe:
(See Pipe)
Cement Lining Presses:
Union Water Meter Co.
Centrifuges:
Bausch & Lomb Optical Co.
Chemical Feed Apparatus:
American Water Softener Co.
E. W. Bacharach & Co.
Builders Iron Foundry
Dorr Co.
International Filter Co.
New York Continental Jewell Filtration Co.
Paradon Co.
Permutit Co.
Ross Valve Mfg. Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Co., Inc.
Chemicals for Laboratory Use:
Difco Laboratories
La Motte Chemical Products Co.
Chemicals for Water Purification:
Diamond Alkali Co.
General Chemical Co.
Jennison-Wright Co.
Pennsylvania Salt Mfg. Co.
Isaac Winkler & Bro.
Chemists and Engineers:
(See Directory of Experts, page 13)
Chlorinators:
Paradon Co.
Wallace & Tiernan Co., Inc.
Chlorine Comparator:
Hellige, Inc.
La Motte Chemical Products Co.
Chlorine, Liquid:
Diamond Alkali Co.
Paradon Co.
Pennsylvania Salt Mfg. Co.
Wallace & Tiernan Co., Inc.
Clarifiers:
Dorr Co.
International Filter Co.
Permutit Co.
Clay Spaders:
Worthington Pump & Machinery Corp.
Cleaning Water Main:
National Water Main Cleaning Co.
Cocks, Curb and Corporation:
Mueller Co.
A. P. Smith Mfg. Co.
Union Water Meter Co.
Color Standard for Turbidity, Nitrates, Total Iron, etc.:
Hellige, Inc.
La Motte Chemical Products Co.
Colorimetric Analysis Equipment:
Hellige, Inc.
La Motte Chemical Products Co.

Concrete Forms:
Alco Products, Inc.
Condensers:
Allis-Chalmers Mfg. Co.
United States Pipe & Foundry Co.
Worthington Pump & Machinery Corp.
Contracting Engineers:
Ambursen Construction Co.
Contractors, Water Supply:
Cook, A. D., Inc.
Layne & Bowler, Inc.
Contractors, Well Drilling:
Cook, A. D., Inc.
Layne & Bowler, Inc.
Copper Sheets:
American Brass Co.
Couplings, Flexible:
DeLaval Steam Turbine Co.
Curb Boxes:
Bingham & Taylor Corp.
H. W. Clark Co.
Columbian Iron Works
Mueller Co.
Dams:
Ambursen Construction Co.
Deodorizer:
Jennison-Wright Co.
Dewatering Pumps:
Pomona Pump Co.
Diaphragms, Pump:
Edson Mfg. Corp.
Diesel Engines:
Worthington Pump & Machinery Corp.
Drills, Rock:
Worthington Pump & Machinery Corp.
Electrically Operated Gate Valves:
Darling Valve & Mfg. Co.
Engineers and Chemists:
(See Directory of Experts, page 13)
Engines:
(See Pumps and Pumping Engines)
Evergreen Trees:
Brown Co.
Feed Water Filters:
American Water Softener Co.
International Filter Co.
Permutit Co.
Ross Valve Mfg. Co.
Feed Water Heaters:
Biggs Boiler Works Co.
Worthington Plump & Machinery Corp.
Feed Water Testing Outfits:
Hellige, Inc.
La Motte Chemical Products Co.
Feed Water Treatment:
American Water Softener Co.
International Filter Co.
Permutit Co.
Filter Rate Controllers and Gages:
(See Rate Controllers)
Filters and Water Softening Plants:
American Water Softener Co.
E. W. Bacharach & Co.
Dorr Co.
Fuller and Everett
International Filter Co.
New York Continental Jewell Filtration Co.
Permutit Co.
Zeolite Chemical Co.
Filtration Plant Equipment:
American Water Softener Co.
E. W. Bacharach & Co.
Builders Iron Foundry
Columbian Iron Works
Difco Laboratories
International Filter Co.
New York Continental Jewell Filtration Co.
Paradon Co.
Permutit Co.
Simplex Valve & Meter Co.
R. D. Wood & Co.
Filtration Sand:
Ottawa Silica Co.
Whitehead Brothers Co.
Fittings, Copper Pipe:
Mueller Co.
Flexible Joints:
United States Pipe & Foundry Co.
R. D. Wood & Co.
Flumes, Steel:
Alco Products, Inc.
Biggs Boiler Works Co.
Petroleum Iron Works Co.
Furnaces:
Mueller Co.
A. P. Smith Mfg. Co.
Gages, Surface, Reservoir and Special Water Works:
American Water Softener Co.
Builders Iron Foundry
H. W. Clark Co.
International Filter Co.
New York Continental Jewell Filtration Co.
Republic Flow Meters Co.
Simplex Valve & Meter Co.
Water Works Equipment Co.
Gate Valves:
(See Valves, Gate)
Gates, Shear and Sluice:
Columbian Iron Works
Ludlow Valve Mfg. Co.
Gears, Speed Reducing:
DeLaval Steam Turbine Co.

Greensand (Zeolite):
Zeolite Chemical Co.
Hose, Suction and Conduction:
Edson Mfg. Corp.
Hydrants, Fire:
Columbian Iron Works
Cook, A. D., Inc.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Rensselaer Valve Co.
Ross Valve Mfg. Co.
A. P. Smith Mfg. Co.
R. D. Wood & Co.
Hydrants, Sprinkling and Flushing:
Columbian Iron Works
Ludlow Valve Mfg. Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Co.
R. D. Wood & Co.
Hydraulically Operated Gate Valves:
Darling Valve & Mfg. Co.
Hydrogen Ion Equipment:
Hellige, Inc.
La Motte Chemical Products Co.
Indicators, Combustion, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Indicators, Flow:
International Filter Co.
Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.
Inspection of Materials:
William R. Conard
Iron Removal Plants:
American Water Softener Co.
E. W. Bacharach & Co.
International Filter Co.
New York Continental Jewell Filtration Co.
Jointing Materials:
Atlas Mineral Products Co.
Hydraulic Development Corp.
Leadite Co., Inc.
Mueller Co.
Jute:
Water Works Equipment Co.
Laboratory Apparatus:
Difco Laboratories
Lead Furnaces:
Water Works Equipment Co.
Lead Wool:
Water Works Equipment Co.
Leak Finders:
H. W. Clark Co.
Globe Phone Mfg. Corp.
Leak Locating Instruments:
Globe Phone Mfg. Corp.
Water Works Equipment Co.
Lime Slakers and Feeders:
International Filter Co.
Liquid Chlorine:
(See Chlorine, liquid)
Machines, Drilling:
Mueller Co.
Machines, Lead Flanging:
Mueller Co.
Manhole Frames and Covers:
Bingham & Taylor Corp.
H. W. Clark Co.
Meters:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders Iron Foundry
Gamon Meter Co.
Hersey Mfg. Co.
National Meter Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Co.
Simplex Valve & Meter Co.
A. P. Smith Mfg. Co.
Thomson Meter Corp.
Union Water Meter Co.
Worthington Pump & Machinery Corp.
Meters (Venturi Type):
Builders Iron Foundry
International Filter Co.
National Meter Co.
Simplex Valve & Meter Co.
Meters, Steam:
Builders Iron Foundry
Meter Boxes:
Bingham & Taylor Corp.
Builders Iron Foundry
H. W. Clark Co.
Columbian Iron Works
Ford Meter Box Co.
Mueller Co.
Pittsburgh Equitable Meter Co.
Meter Couplings:
Badger Meter Mfg. Co.
Buffalo Meter Co.
H. W. Clark Co.
Gamon Meter Co.
Hersey Mfg. Co.
Mueller Co.
National Meter Co.
Pittsburgh Equitable Meter Co.
Thomson Meter Corp.
Union Water Meter Co.
Meter Coupling Yokes:
H. W. Clark Co.
Ford Meter Box Co.
Mueller Co.
Meter Reading and Record Books:
Buffalo Meter Co.
Meter Testers:
Badger Meter Mfg. Co.

Buffalo Meter Co.
Builders Iron Foundry
H. W. Clark Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Mueller Co.
National Meter Co.
Pittsburgh Equitable Meter Co.

Meter Washers:
Mabbs Hydraulic Packing Co.

Microscopes:
Bausch & Lomb Optical Co.

Mixing Kettles:
Alco Products, Inc.

Motors, Electric:
Allis-Chalmers Mfg. Co.

Municipal Castings:
Columbian Iron Works

Oil Engines:
Allis-Chalmers Mfg. Co.
Worthington Pump & Machinery Corp.

Packing, Rawhide:
Mabbs Hydraulic Packing Co.

Pavement Breakers:
Worthington Pump & Machinery Corp.

Penstocks, Steel:
Alco Products, Inc.
Biggs Boiler Works Co.
Petroleum Iron Works Co.

Photo-Micrographic Apparatus:
Bausch & Lomb Optical Co.

Photographic Apparatus:
Bausch & Lomb Optical Co.

Pipe, Brass:
American Brass Co.
Kennedy Valve Mfg. Co.
A. P. Smith Mfg. Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Builders Iron Foundry
Central Foundry Co.
Lead Lined Iron Pipe Co.
McWane Cast Iron Pipe Co.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood & Co.

Pipe, Cement Lined:
American Cast Iron Pipe Co.
Biggs Boiler Works Co.
Builders Iron Foundry
McWane Cast Iron Pipe Co.
Petroleum Iron Works Co.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood & Co.

Pipe, Concrete:
Lock Joint Pipe Co.

Pipe, Copper:
Mueller Co.

Pipe Cutting Machines:
A. P. Smith Mfg. Co.
Water Works Equipment Co.

Pipe Jointing Materials:
(See Jointing Materials)

Pipe, Lead Lined (and Fittings):
Biggs Boiler Works Co.
Lead Lined Iron Pipe Co.
Petroleum Iron Works Co.

Pipe Locators:
H. W. Clark Co.
Water Works Equipment Co.

Pipe, Pressure, Riveted and Welded:
Alco Products, Inc.
Biggs Boiler Works Co.
East Jersey Pipe Co.
Petroleum Iron Works Co.
Steel Watermains Association

Pipe, Steel:
Alco Products, Inc.
Biggs Boiler Works Co.
East Jersey Pipe Co.
Petroleum Iron Works Co.
Steel Watermains Association

Pipe, Tin Lined:
Biggs Boiler Works Co.
Petroleum Iron Works Co.

Pressure Regulators:
H. W. Clark Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.
Simplex Valve & Meter Co.
Union Water Meter Co.

Provers, Water:
Pittsburgh Equitable Meter Co.

Pumps and Pumping Engines:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Edson Mfg. Corp.
Byron Jackson Co.
Ross Valve Mfg. Co.
Sterling Engine Co.
Worthington Pump & Machinery Corp.

Pumps, Attached to Steam Turbines:
Byron Jackson Co.
Cook, A. D., Inc.
Pomona Pump Co.

Pumps, Centrifugal:
Byron Jackson Co.
Layne & Bowler, Inc.
Worthington Pump & Machinery Corp.

Pumps, Deep Well:
Byron Jackson Co.
Cook, A. D., Inc.
Layne & Bowler, Inc.
Pomona Pump Co.

Worthington Pump & Machinery Corp.
Pumps, Diaphragm (Hand and Power):
Edson Mfg. Corp.
Pumps, Power:
Cook, A. D., Inc.
Pomona Pump Co.
Pumps, Sump:
Byron Jackson Co.
Cook, A. D., Inc.
Pomona Pump Co.
Pumps, Turbine:
Byron Jackson Co.
Cook, A. D., Inc.
Pomona Pump Co.
Rate Controllers:
American Water SoftenerCo.
Builders Iron Foundry
International Filter Co.
New York Continental Jewell Filtration Co.
Simplex Valve & Meter Co.
Recarbonating Plants:
E. W. Bacharach & Co.
International Filter Co.
Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Recording Instruments:
International Filter Co.
Permutit Co.
Water Works Equipment Co.
Reforestation (Evergreen Trees):
Brown Co.
Refractometers:
Bausch & Lomb Optical Co.
Reservoirs, Steel:
Pittsburgh-Des Moines Steel Co.
Rock Drills:
Worthington Pump & Machinery Corp.
Sand, Filtration:
Ottawa Silica Co.
Whitehead Brothers Co.
Service Clamps, Galvanized:
Mueller Co.
Shaft Linings:
Alco Products, Inc.
Shovels, Underground:
Allis-Chalmers Mfg. Co.
Sleeves and Valves, Tapping:
Ludlow Valve Mfg. Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Water Works Equipment Co.
R. D. Wood & Co.
Sleeves, Tapping Machine:
Darling Valve & Mfg. Co.
Water Works Equipment Co.
Soda Ash:
Diamond Alkali Co.
Isaac Winkler & Bro.
Soda, Caustic:
Diamond Alkali Co.
Softeners and Purifiers:
American Water Softener Co.
International Filter Co.
Permutit Co.
Special Vessels:
Alco Products, Inc.
Biggs Boiler Works Co.
Stacks:
Biggs Boiler Works Co.
Petroleum Iron Works Co.
Standpipes, Steel:
Biggs Boiler Works Co.
Pittsburgh-Des Moines Steel Co.
Steel Plate Construction:
Biggs Boiler Works Co.
Petroleum Iron Works Co.
Storage Tanks:
Alco Products, Inc.
Biggs Boiler Works Co.
Sulphate of Alumina:
(See Alum)
Sump Pumps:
Cook, A. D., Inc.
Pomona Pump Co.
Worthington Pump & Machinery Corp.
Swimming Pool Refiltration System:
E. W. Bachrach & Co.
International Filter Co.
Swing Check Valves:
Columbian Iron Works
Darling Valve & Mfg. Co.
Tanks, Elevated Steel:
Pittsburgh-Des Moines Steel Co.
Tanks, Mixing:
Alco Products, Inc.
Biggs Boiler Works Co.
Dorr Co.
Tanks, Steel:
Biggs Boiler Works Co.
H. W. Clark Co.
Petroleum Iron Works Co.
Pittsburgh-Des Moines Steel Co.
Tapping Machines:
Mueller Co.
A. P. Smith Mfg. Co.
Water Works Equipment Co.
Tapping Machine Sleeves:
(See Sleeves, Tapping Machine)
Tapping Sleeves:
(See Sleeves and Valves, Tapping)
Taste and Odor Removal Plants:
International Filter Co.
Taste Removal:
Jennison-Wright Co.
Trees, Evergreen:
Brown Co.

Turbine Pumps:
Cook, A. D., Inc.
Pomona Pump Co.
Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Turbines, Water:
DeLaval Steam Turbine Co.
Valve Boxes:
H. W. Clark Co.
Columbian Iron Works
Ford Meter Box Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood & Co.
Valve Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.
Valves, Air:
Darling Valve & Mfg. Co.
Valves, Altitude:
Golden-Anderson Valve Specialty Co.
Valves, Check, Flap, Foot, Hose, Mud and Plug:
Columbian Iron Works
Cook, A. D., Inc.
Ludlow Valve Mfg. Co.
Valves, Compounding:
Union Water Meter Co.
Valves, Float:
Golden-Anderson Valve Specialty Co.
Valves, Gate:
Columbian Iron Works
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
United States Pipe & Foundry Co.
R. D. Wood & Co.
Valves, Large Diameter:
Alco Products, Inc.
Valves, Regulating:
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.
Union Water Meter Co.
Valves, Swing Check:
Columbian Iron Works
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Water Cranes:
Ludlow Valve Mfg. Co.
Watershed Protection (Evergreen Trees):
Brown Co.
Water Softener (Hot Lime Soda):
Permutit Co.
Water Softener (Zeolite):
International Filter Co.
Permutit Co.
Zeolite Chemical Co.
Water Softening Plants:
American Water Softener Co.
E. W. Bacharach & Co.
Dorr Co.
Fuller and Everett
International Filter Co.
New York Continental Jewell Filtration Co.
Permutit Co.
Zeolite Chemical Co.
Water Supply Contractors:
Cook, A. D., Inc.
Layne & Bowler, Inc.
Water Testing Apparatus:
Hellige, Inc.
Water Treatment Plants:
American Water Softener Co.
E. W. Bacharach & Co.
International Filter Co.
Permutit Co.
Zeolite Chemical Co.
Water Waste Detection:
Globe Phone Mfg. Corp.
Pitometer Co.
Simplex Valve & Meter Co.
Water Works Construction, General:
Pittsburgh-Des Moines Steel Co.
Well Castings:
Layne & Bowler, Inc.
Well Drilling Contractors:
Cook, A. D., Inc.
Edward E. Johnson, Inc.
Layne & Bowler, Inc.
Well Screens:
Cook, A. D., Inc.
Edward E. Johnson, Inc.
Layne & Bowler, Inc.
White Filtration Sand:
Ottawa Silica Co.
Zeolite (Water Softener):
International Filter Co.
Permutit Co.
Zeolite Chemical Co.
Zeolites (Natural and Synthetic Minerals):
Permutit Co.

ALPHABETICAL LIST OF ADVERTISERS

	PAGE
Alco Products, Inc.	33
Alvord, Burdick & Howson	13
Ambursen Construction Co	13
American Brass Co	19
American Public Health Assn	16
American Water Softener Co	30
Atlas Mineral Products Co	20
Bacharach, E. W., & Co	13
Bausch & Lomb Optical Co	20
Biggs Boiler Works Co	vi
Black & Veatch	13
Buffalo Meter Co	35
Burns & McDonnell Engineering Co	13
Byron Jackson Co	18
Caird, James M	13
Central Foundry Co	10
Chester, J. N., Engineers	13
Cole, Edward S	13
Conard, William R	13
Cook, A. D., Inc	13
Darling Valve & Mfg. Co	21
DeLaval Steam Turbine Co	43
DuPont Rayon Co	36
East Jersey Pipe Co	11
Ford Meter Box Co	38
Fuller & Everett	14
Fuller & McClintock	14
Golden-Anderson Valve Specialty Co	12
Hersey Mfg. Co	27
Hill, Nicholas S., Jr	14
Hunt, Robert W., Co	14
Hydraulic Development Corp	23
Industrial Chemical Sales Co	26
International Filter Co	9
Jackson, Byron, Co	18
Jennison-Wright Co	32
Johnson, Edward E., Inc	14
Kennedy Valve Mfg. Co	31
Knowles, Morris, Inc	14
Lead Lined Iron Pipe Co	38
Leadite Co	cover 4
Lock Joint Pipe Co	i
Ludlow Valve Mfg. Co	28
Mabbs Hydraulic Packing Co	30
Metcalf & Eddy	14
Mullergren, Arthur L	14
National Meter Co	24
National Water Main Cleaning Co.	22
Neptune Meter Co	37
Ottawa Silica Co	10
Pearse, Greeley & Hansen	14
Pease Laboratories, Inc.	14
Permutit Co	36
Pirnie, Malcolm	14
Pitometer Co	14
Pittsburgh-Des Moines Steel Co	10
Pittsburgh Equitable Meter Co	44
Positions Wanted	20, 41
Potter, Alexander	15
Potts, Clyde	15
Rensselaer Valve Co	25
Ross Valve Mfg. Co., Inc	15
Sanborn & Bogert	15
Scofield Engineering Co	15
Simplex Valve & Meter Co	29
Sterling Engine Co	39
Union Water Meter Co	17
United States Pipe & Foundry Co.	ii
Van Cleve Laboratories, Inc	15
Wallace & Tiernan Co., Inc.	cover 3
Warren Foundry & Pipe Corp	38
Water Works Equipment Co	36
Weston & Sampson	15
Williams & Wilkins Co	39
Wood, R. D., & Co	cover 2
Zeolite Chemical Co	22

Just Like Mountain Spring Water

INFILCO

PRODUCTS

- Aerators
- Automatic Boiler Blowdown
- Basin Level Controllers
- Chemical Proportioners
- Clarifiers
- Coagulant Feeders
- Dechlorinators
- Depth Gauges
- Directional Flow Controllers
- Disk Filters
- Dry Chemical Feeders
- Filtration Plants
- Filter Underdrains
- Flow Indicators
- Gravity Filters
- Hot-Flow Water Softeners
- Hydraulic Valve Controls
- Hydrodarco Purifiers
- Iron Removal Plants
- Loss of Head Gauges
- Lime-Soda Water Softeners
- Lime Slakers and Feeders
- Manometers
- Orifice Feed Boxes
- Oil Removal Filters
- Proportioning Equipment
- Pressure Filters
- Recarbonating Equipment
- Rate of Flow Controllers and Gauges
- Sampling Tables
- Solenoid Operated 4-Way Valves
- Steam and Gas Purifiers
- Strainers and Distributing Nozzles
- Swimming Pool Filters and Equipment
- Sterilizers
- Taste and Odor Removal Plants
- Venturi Tubes and Infilco Meters
- Water Stills
- Wet Chemical Feeders
- Zeolite Water Softeners

IN THESE enlightened days, the consumer takes the purity of his drinking water as a matter of course. Rightly so, since he foots the bills of all safe-guarding agencies encompassed in Government, State and local health authorities—and his funds have also helped develop the local source of supply and build the purification plant.

He is prone to judge the fitness of the water he drinks solely on the basis of how it tastes, smells or looks. If the water does not measure up to his standards, gauged by these three things, he criticizes the men in his community responsible for water production.

"Just like mountain spring water." That is what will be said of the water if you use **Powdered**

HYDRODARCO

—the activated carbon manufactured expressly for water purification. And, the treatment is so simple, so economical, so universally effective in removing objectionable tastes and odors from water, and can be so easily put into operation without disturbing existing routine purification, that no community can afford to be without it.

Powdered Hydrodarco—a few bags or a carload —should be in every water purification plant, for continuous application—or available to meet any emergency that may arise.

International Filter Co.

Water Softening and Filtration Plants

General Offices

59 East Van Buren Street, Chicago

INTERNATIONAL

UNIVERSAL
CAST IRON PIPE

THE CENTRAL FOUNDRY COMPANY

420 Lexington Ave., New York

CHICAGO, ILL. 332 S. Michigan Avenue
BESSEMER, ALA. Central Foundry Bldg.
DALLAS, TEXAS Praetorian Building
OKLAHOMA CITY, OKLA. Hershowitz Building
EL PASO, TEXAS 2212 Montana Street
DENVER, COLO. 1453 Wazee Street
SAN FRANCISCO, CALIF. 100 Potrero Avenue

FILTER SILURIAN Sterilized SAND
MAGNIFIED

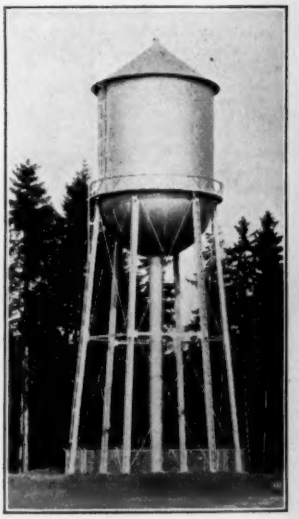
A Washed, Dried, Screened and Processed White Silica Sand
Wholly Free from Silt, Clay or Other Foreign Substance
Dependable Supply Winter and Summer

Prepared and Shipped only by the
OTTAWA SILICA COMPANY
OTTAWA. ILLINOIS

Good Water Service Demands Good Tanks

The 250,000 gallon "Pittsburgh-Des Moines" tank shown at the right facilitates good water service for the Capital City of Olympia, Washington. This was the third PDM tank erected for Olympia—a 1931 repeat order following the satisfactory performance records of a 200,000 gallon tank in 1925 and another 250,000 gallon tank in 1930.

The diameter is 32 feet; height to balcony is 74 feet 6 inches.



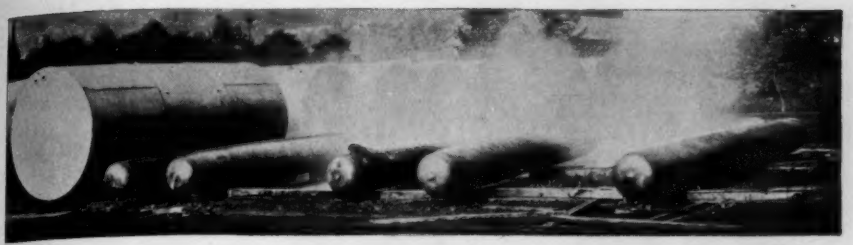
QUALITY PITTSBURGH TANKS DES MOINES TANKS

PDM PRODUCTS

Elevated Tanks
Steel Standpipes
Steel Pipe Lines
Structural Steel Work
General Steel Plate Fabrication
Steel Grandstands
Highway Bridges
Complete Water Works Systems
Water Treating Plants
Gasoline and Oil Tanks
Municipal Incinerators

Pittsburgh-Des Moines Steel Company
3424 Neville Island, Pittsburgh, Pa.

Room 921, 270 Broadway, New York, N. Y. 925 Tuttle St., Des Moines, Iowa
Chicago Atlanta Dallas San Francisco Seattle



It Burst . . . . *but not at the joint!*

This bursting test of Lock-Bar Steel Pipe was made at the Lock-Bar plant, Leetsdale, Pa.

Size of pipe—30 in. dia., 5/16 in. plate. Five regular sections of Lock-Bar pipe were tested.

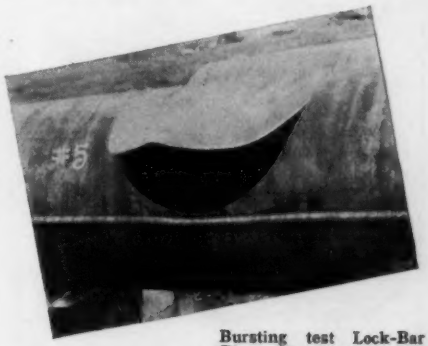
In every case the pipe burst in the plate—not in the joint. Bursting pressures ranged from 1080 lbs. to 1200 lbs.

The facts speak for themselves and show the strength and dependability of the Lock-Bar joint.

DESTRUCTIVE TESTS OF 30-INCH LOCK-BAR PIPE

Pipe No.	Breaking Pressure, Lb. Per Sq. In.	Strength of Plate, Lb. per Sq. In.	Increase in Circumference In.
1	1,160	61,430	7
2	1,080	56,950	7
3	1,200	57,930	5¼
4	1,140	56,270	5
5	1,140	60,430	12

Bursting test Lock-Bar Pipe. Size of pipe, 30 in. x 5/16 in. Burst in plate at 1140 lbs. pressure. Stretch in circumference 5 in.



Bursting test Lock-Bar Pipe. Size of pipe, 30 in. x 5/16 in. Stretch in circumference, 12 in. Pressure maintained 30 minutes before plate broke at 1140 lbs.

EAST JERSEY PIPE COMPANY

7 Dey Street, New York, N. Y.

LOCK-BAR

STRONG AS THE *Before Closing* PLATE ITSELF

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Altitude Valves

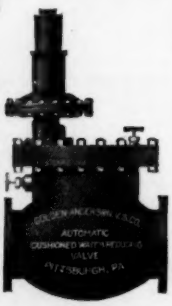
We have enlightened many a water user in municipalities, in industrial plants and on railroads, as to the adaptability of these Golden-Anderson Valves, and as to their function of SAVING, and of eliminating troubles.
For automatically maintaining Uniform Stage of Water in Tank, Reservoir or Standpipes. Doing away with the annoyance of Freezing and Float Fixtures inside or outside of Tanks.
"Three Ways of Closing These Valves:"
1st—Automatically, by water
2nd—By Electricity, if desired
3rd—By Hand
May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe.
No valves or fixtures inside or outside.
All Sizes 2" to 24 in.

"Valves Guaranteed"!
"HOSTS OF REFERENCES"
Valves cushioned at all times by air and water
No water hammer or bursting mains

City of Los Angeles, Calif. has 30 of these valves in constant service.

GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.



GOLDEN-ANDERSON
Patent Automatic Cushioned Controlling Float Valves

They carry a constant water level in feed water heaters by perfectly controling the flow of makeup water.

Operated by protected enclosed copper float.

Cushioned by both air and water.

Operate without hammering, sticking or chattering. No metal-to-metal seats. Made angle or straightway.

Sizes 1 in. to 24 in.

GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipes, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle—Most Satisfactory Float Valves Known.
4. No Metal-to-Metal Seats — No Water Hammer or Shock.
5. Cushioned by Water and Air.

Angle or Globe.
Sizes to 24 in.

GOLDEN-ANDERSON
Patented Cushioned Electric Water Service Valves

Especially adapted for Diesel Engine cooling.

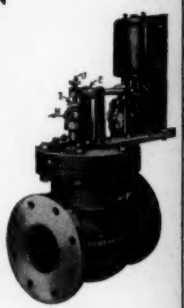
Quick opening and closing.

No water hammer or shock.

Cushioned in opening and closing.

For A. C. or D. C. circuits.

Size 2" to 24" in angle or globe patterns.



Golden-Anderson Valve Specialty Co., 1215 Fulton Bldg., Pittsburgh, Pa.

DIRECTORY OF EXPERTS

JOHN W. ALVORD — LOUIS R. HOWSON
CHARLES B. BURDICK — DONALD H. MAXWELL

ALVORD, BURDICK & HOWSON
ENGINEERS
Water Works, Water Purification, Flood Relief, Sewerage, Sewage Disposal, Drainage, Appraisals, Power Generation
Civic Opera Building — Chicago

AMBURSEN DAMS
Hydroelectric Developments
Water Supply and Irrigation Dams
DAMS ON DIFFICULT FOUNDATIONS
AMBURSEN CONSTRUCTION CO., INC.
295 Madison Ave. New York — Alexander Bldg. San Francisco

E. W. Bacharach & Company
Specialists; furnishing and installing complete equipment for Water Purification Plants of any type, any purpose, any capacity.
Rialto Building — Kansas City, Mo.

E. B. BLACK — N. T. VEATCH, JR.
A. P. LEARNED — E. H. DUNMIRE — J. F. BROWN
C. L. DODD — F. M. VEATCH

BLACK & VEATCH
Consulting Engineers
Sewerage, Sewage Disposal, Water Supply, Water Purification, Electric Lighting, Power Plants, Valuations, Special Investigations and Reports.
Kansas City, Mo., Mutual Building
307 South Hill St., Los Angeles, Calif. and 36 West 44th Street, New York City

Burns & McDonnell Engineering Co.
McDonnell-Smith-Baldwin-Lambert
Consulting Engineers
Waterworks, Sewerage, Lighting, Appraisals, Rate Investigations
Kansas City, Mo., Interstate Bldg.
Los Angeles, Cal., Western Pacific Bldg.

JAMES M. CAIRD
Cannon Bldg., Broadway and Second Street
Troy, N. Y. — Assoc. Am. Soc. C.E.
Chemist and Bacteriologist
Water Analyses
SPECIALTIES—Tests of Filter Plants; Examinations and Reports upon Proposed Sources of Water Supply; the Copper Sulphate Treatment for Algae; Expert Testimony.

THE J. N. CHESTER ENGINEERS
J. N. Chester, J. T. Campbell, D. E. Davis
J. F. Laboon, E. Bankson
Hydraulic and Sanitary Engineers
Water Works, Water Filtration, Appraisements and Reports, Sewerage, Sewage Disposal, Operation of Properties
717 Liberty Avenue — PITTSBURGH, PA.

EDWARD S. COLE
Hydraulic Engineer
50 Church St., New York City

Wm. R. Conard
Assoc. Member Amer. Soc. C. and Mech. Engrs. Member Amer. and New England W. W. Assocs. Reports, Specifications, Designs, Inspections and Tests of Materials and Construction
Burlington — New Jersey

Well Strainers and Deep-Well Turbine Pumps
A reciprocal relation, the life and functioning of the one depending much on the other.
A. D. COOK, INC.
Lawrenceburg — Indiana

Fuller & Everett
(formerly Hazen & Everett)
Civil Engineers
Weston E. Fuller C. M. Everett
WATER WORKS
Design, Construction, Operation, Valuations, Rates
25 W. 43rd Street - New York City

METCALF & EDDY
ENGINEERS
Harrison P. Eddy, Charles W. Sherman, Almon L. Fales, Frank A. Marston, John P. Wentworth, Harrison P. Eddy, Jr., Arthur L. Shaw, E. Sherman Chase
Water, Sewage, Drainage, Refuse and Industrial Wastes Problems
Laboratory, Valuations
Statler Bldg. Boston

FULLER & McCLINTOCK
Engineers
NEW YORK, 170 Broadway
Philadelphia, Pa.
Pennsylvania Bldg., 15th and Chestnut Sts.

ARTHUR L. MULLERGREN
CONSULTING ENGINEER
SPECIALIST IN
Electric Light, Power and Water Pumping
202 Fairfax Building
Kansas City, Mo.

NICHOLAS S. HILL, Jr.
CONSULTING ENGINEER
WATER SUPPLY—SEWAGE DISPOSAL—HYDRAULIC DEVELOPMENTS.
Reports, Investigations, Valuations, Rates, Design, Construction, Operation, Management
Chemical and Biological Laboratories
112 E. 19th St. New York City

PEARSE, GREELEY & HANSEN
HYDRAULIC AND SANITARY ENGINEERS
Water Supply, Water Purification, Sewerage, Sewage Treatment, Refuse Disposal Investigations, Reports, Designs, Construction Supervision, Appraisals and Consultation.
6 North Michigan Ave., Chicago, Illinois

ROBERT W. HUNT COMPANY
ENGINEERS
INSPECTION—TESTS—CONSULTATION
Inspection and Tests of Materials
Cast Iron Pipe and Fittings a Specialty
Supervision of Construction
Special Tests and Investigations
General Offices and Laboratories
22nd Floor Insurance Exchange
CHICAGO
Offices in all principal cities

Pease Laboratories, Inc.
39 West 38th Street, New York
Analysis of the water supplies for municipalities, industrial plants, private estates and camps. Swiming pool control.
Chemists Field Sanitary Surveys
Bacteriologists Consultants

WELL SCREENS
To meet your problems in sand and gravel wells.
EDWARD E. JOHNSON, INC.
2304 Long Avenue,
St. Paul, Minn

Malcolm Pirnie
Engineer
Malcolm Pirnie Charles F. Ruff
Water Supply, Treatment, Sewerage
Reports, Plans, Estimates,
Supervision and Operation,
Valuation and Rates.
25 W. 43d St., New York, N. Y.

MORRIS KNOWLES, INC.
Engineers
Water Supply and Purification, Sewerage and Sewage Disposal, Valuations, Laboratory, City Planning.
PITTSBURGH, PA.

THE PITOMETER COMPANY
Engineers
Water Waste Surveys
Trunk Main Surveys
Water Distribution Studies
Penstock Gaugings
50 Church St. New York City

ALEXANDER POTTER

CONSULTING ENGINEER

Specialties: Water Supply and Sewerage

50 Church St. **New York City**

Telephone 5501 Cortlandt

Scofield Engineering Co.

CONSULTING ENGINEERS

Water, Gas, Electric Plants and Distribution Systems

Appraisals, Valuations and Reports
Design—Supervision—Operation

PHILADELPHIA, PENNA.

CLYDE POTTS

M. Am. Soc. C. E.

CONSULTING SANITARY ENGINEER

30 Church Street - - New York

Sewerage and Sewage Disposal
Water Works and Water Supply
Reports, Plans, and Estimates

WATER ANALYSIS

Our Laboratories are equipped with standardized apparatus for water analyses.

Our graduate chemists render dependable reports.

VAN CLEVE LABORATORIES, Inc.

322 So. 4th St., Minneapolis, Minn.

Sanborn & Bogert

CONSULTING ENGINEERS

Water Supply, Sewerage, Dams, Tunnels, and Foundations. Concrete Structures.

New York 30 Church St.

Weston & Sampson

Robert Spurr Weston **G. A. Sampson**

Consulting Engineers for Water Supply, Water Purification, Sewerage, Disposal of Sewage, and Municipal and Factory Wastes. Operation of Purification Plants and Sanitary Analyses.

14 Beacon St. **Boston, Mass.**

THE STANDARD FOR 50 YEARS

Automatic Pressure Control Valves
Water Works Specialties
Altitude — Pressure Reducing — Surge Relief and Combination Valves
Portable Fire Hydrants
Hydraulic Booster Pumps

ROSS VALVE MFG. CO., INC. TROY, N. Y.

ADVERTISING
in this
JOURNAL
means
more BUSINESS

SECOND ANNUAL YEAR BOOK
AMERICAN PUBLIC HEALTH ASSOCIATION

Contains reports of Committees, including:

Methods for the Investigation of Waterways Pollution (Report of the Committee on Waterways Pollution)

Lessons Taught by Drought in Maintaining Safe Water Supplies (Report of the Committee on Water Supply)

Promotion of Environmental Sanitation

Sewage Disposal

Disaster Relief

Scope and Policy

Milk Supply

Ready February 1

Price $1.50

AMERICAN PUBLIC HEALTH ASSOCIATION

450 SEVENTH AVENUE NEW YORK, N. Y.

Are You a Member of
The American Public Health Association?

AS ONE who plays an active part in the control of environment, whether it be in protecting the water supply, in sewage disposal, or in any practical sanitary problems, you are a public health worker and therefore eligible for membership in the American Public Health Association. Membership will provide contact with the keenest minds in your profession. It will keep you up-to-date with the latest and best developments in the public health movement. Through its official publication, the American Journal of Public Health, it will make available to you the papers emanating from its powerful Public Health Engineering Section, which constitute some of the outstanding contributions to the literature.

— — — — — — — — — — — — — [*COUPON*] — — — — — — — — — — — —

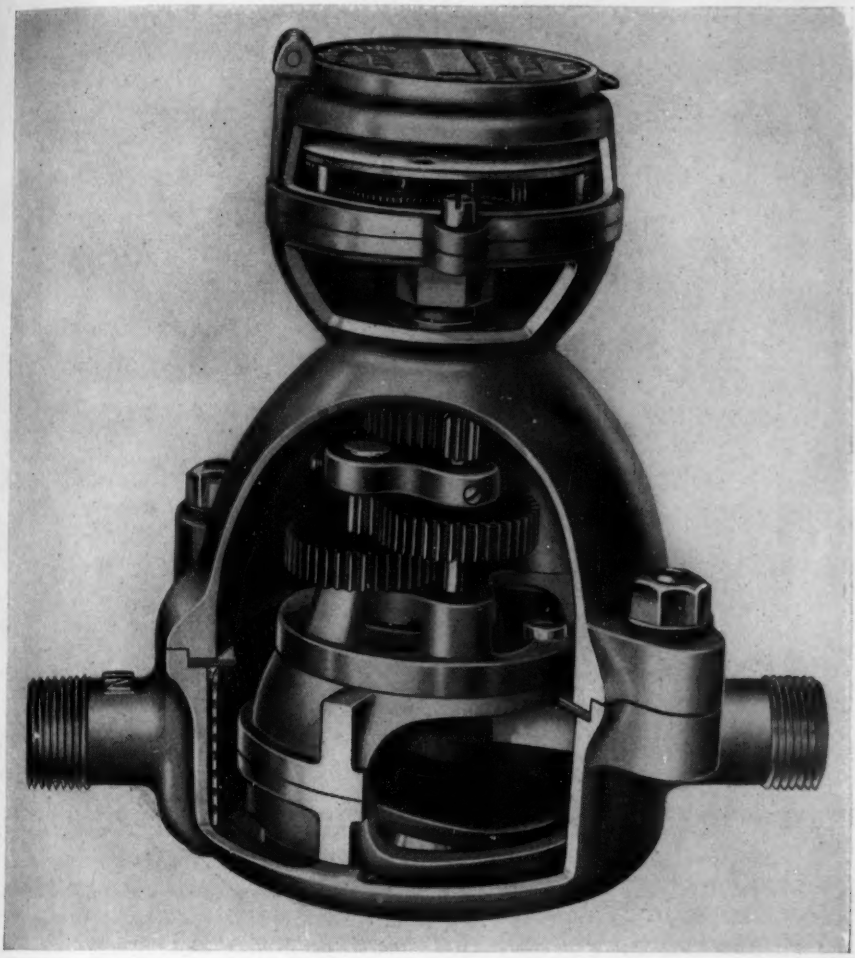
AMERICAN PUBLIC HEALTH ASSOCIATION
450 Seventh Avenue, New York, N. Y.

Please tell me more about membership in the AMERICAN PUBLIC HEALTH ASSOCIATION.

Name.....

Address.....

KING BB METER



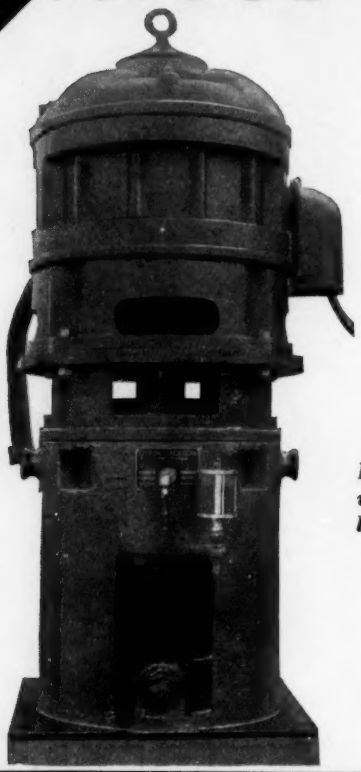
Direct outlet type. Open or oil enclosed gear train. With or without frost relief. A notable advance in meter construction.

UNION WATER METER CO., Worcester, Mass.

INCORPORATED 1868

WATER METERS *EASY-TURNING STOPS*
CHRONOMETER VALVES *PRESSURE REGULATORS*

Water!



For full details write for Bulletin No. 316

Byron Jackson Deepwell Turbines for drilled wells provide a reliable and economical water supply for municipalities in capacities from 10 gallons to 10,000 gallons of water per minute.

In all parts of the country these automatically operated, highly efficient Deepwell Turbines have solved problems in cutting operating costs for water works, industries and general construction work.

The Deepwell Turbine pictured here was recently installed for the City of Waycross, Georgia, where it delivers 1800 gallons per minute.

BYRON JACKSON

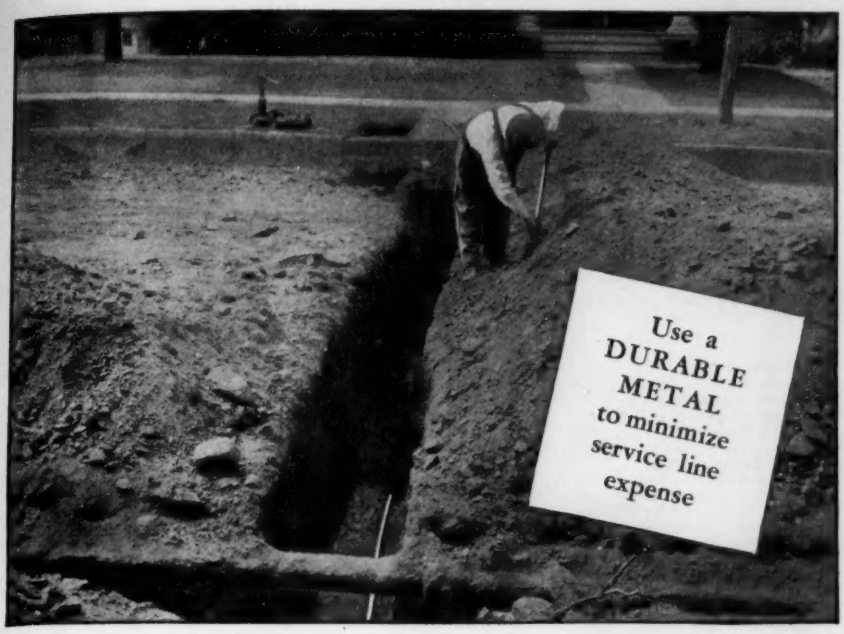
CENTRIFUGAL PUMPS FOR EVERY SERVICE

BYRON JACKSON CO.

Factories: Berkeley, Cal. Bethlehem, Pa. Los Angeles, Cal.

Branches: New York and Chicago

Visalia Tulsa Detroit Portland Salt Lake



Digging costs money ... and good will

TEARING up streets and lawns to replace service lines is costly to the water company . . . not only in money, but in good will. Rustless, ductile copper tubes provide the best protection against such service line failure . . . and expense.

Anaconda Deoxidized Copper Water Tubes are easy to install. Joints are quickly made with special fittings and the tubes may be bent cold to avoid obstructions. Special deoxidization increases their strength and corrosion-resistance. Obtainable in straight lengths and in coils. The recommended wall thickness for one-half inch tube is .049 in. and, for three-quarter inch, .065 in.

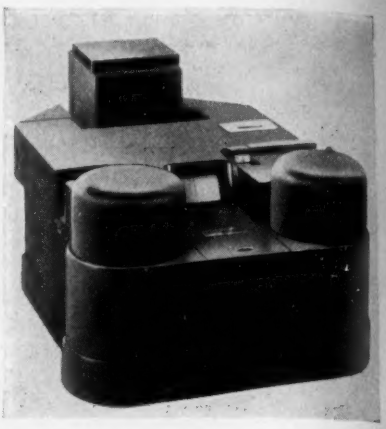
In this product, as in all others that bear the Anaconda trade-mark, every precaution is taken to assure uniform, dependable quality. For your protection the word ANACONDA is stamped at frequent intervals in each coil and length.

ANACONDA
from mine to consumer

THE AMERICAN BRASS COMPANY
General Offices: Waterbury, Connecticut

ANACONDA COPPER & BRASS

Speed . . . Accuracy Simplicity Get These—*PLUS Greater Range with the* Exton Photoelectric Scopometer



THIS revolutionary new instrument, by Bausch & Lomb, enables the water works laboratory to make great time savings in turbidimetric and colorimetric determinations. Turbidity of reservoir and effluent water may be read with unprecedented accuracy, and either referred to standards or recorded in arbitrary units.

The photoelectric principle on which this revolutionary instrument is based, permits a speed and accuracy heretofore impossible in this type of work. All except the smallest laboratories will find that in a very short time this new Scopometer has paid for itself in superior results and in time and labor saved.

Extended manipulation and the personal factor, common causes of error in work of this type, are entirely eliminated.

This instrument operates on the "null" method, requiring no matching of colors or intensities. A series of standards for any substance, covering a range broad enough to include all future samples, is simply prepared and charted, thus direct comparison with a standard is no longer necessary.

In many water laboratories the new Exton Photoelectric Scopometer supersedes every current method of colorimetric and turbidimetric determination. You will find the detailed facts on its operation interesting, write for them.

BAUSCH & LOMB OPTICAL COMPANY

633 St. Paul St. Rochester, N. Y.

USE MINERALEAD

For Jointing Bell and Spigot Water Mains

Easy handling, ingot form—Impervious to moisture—Absolute uniformity—Easy melting—Rapid pouring—No caulking——Less initial leakage—Bell holes unnecessary—A saving in cost of material and labor.

Send for Catalog

THE ATLAS MINERAL PRODUCTS CO. of Pennsylvania MERTZTOWN, PENNA.

Established 1892

Position Wanted

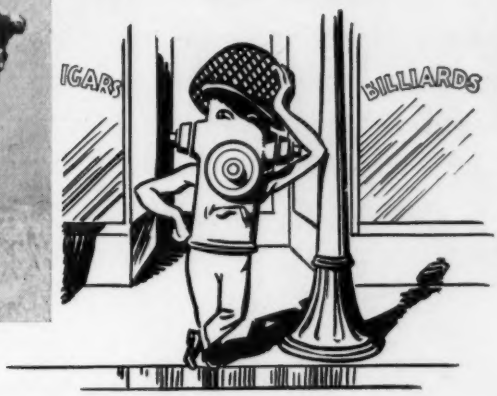
Designer thoroughly experienced in all phases of water works design and construction practice. Member A.W.W.A. and Assoc. Mem. A.S.C.E. Age 37, married, available immediately. Capable of taking charge of design if required. Also aggregate of three years on outside work.

Inquire of

American Water Works Association

29 W. 39th Street New York, N. Y.

A TOUGH CUSTOMER



THE world loves a fighter—one who can take it and return the compliment. In the case of fire hydrants this rugged toughness, which is so much a part of every Darling Fire Hydrant, means real cash savings for the city.

Users of our Hydrants tell us that when truck or motor car collisions occur with Darling Fire Hydrants, there is practically no damage to the Hydrant except possibly a broken nozzle cap or bonnet or perhaps the Hydrant is pushed over on its side. On the other hand, the car or truck never fares so well. It's generally damaged so that it cannot get away. The water company or municipal authorities can fix the responsibility and collect damages.

We do not say that Darling Fire Hydrants *cannot* be broken. But the extra large barrel, its thick walls, its splendid design and material, has in practically all instances withstood such collision abuse with no more injury to the Darling Hydrant than mentioned. Specifying them is a sure way of affording your city an economical and permanent fire protection.

Makers of Gate Valves in all sizes for water works plants.

DARLING VALVE & MFG. CO.

Williamsport, Pa.

New York Oklahoma City Houston

DARLING
FIRE HYDRANTS

CLEAN YOUR WATER MAINS

One does not have to be an expert mathematician to figure out that a clogged water main calls for a stronger pressure and that in turn calls for more coal—and literally burning up money. We can show you how to get dollar for dollar value out of every ton of coal. We can show you how to clean the water mains quickly and cheaply. Send us your address—that's all we ask of you.

National Water Main Cleaning Co.

CHURCH AND DEY STREETS

NEW YORK CITY

MUNICIPAL versus INDIVIDUAL

Water Softening

An article on this subject by Charles P. Hoover, Chemist in Charge of the Columbus (Ohio) Water Softening and Purification Works, will be sent on request.

Mr. Hoover discusses such topics as these: What is hard water and where is it found? The inconveniences of hard water. Estimates of soap losses caused by hard water. Bad effects of hard water on plumbing, heating systems, boiler tubes, etc. Savings to consumers effected by the use of soft water. Does water softening affect the taste? How is hard water softened? How much does it cost?

Send for this Booklet

Zeolite Chemical Company

144 Cedar Street New York, N. Y.

ZECO GREENSAND ZEOLITE

End supports 34 feet apart. 100 lbs. pressure still in line and deflection of over 11 inches with joint still tight.

ELIMINATE THAT LEAKAGE

LEAKY joints have a bearing on many of the problems which water company and water department officials are continually faced with. Unaccounted for water—excessive pumping charges—digging up costly pavements—even renewing pipe lines on account of lowered carrying capacity. Many of these worries can be avoided by making all new joints with Hydro-Tite.

Should a pipe line jointed with Hydro-Tite settle, as shown in the above picture, the joints will remain tight. Lines jointed with Hydro-Tite remain tight year after year and systems completely installed with Hydro-Tite joints are the tightest on record.

Hydro-Tite joints never blow out—have a record of over 20 years—require no caulking and save from 50% to 75% as compared with lead. Write for information on any phase of joint making.

HYDRAULIC DEVELOPMENT CORPORATION

Main Sales Office: **50 Church Street, New York, N. Y.**
General Offices and Works: **80 Boylston Street, Boston, Mass.**

HYDRO-TITE

Reg. U. S. Pat. Off.

A DEPENDABLE SELF-CAULKING JOINT COMPOUND

METERS

In Oscillating and Rotary Piston, Disc, Velocity, Compound and Venturi types. In sizes from small domestic models up to giants for full flows of mains. All of the highest quality, backed by a meter making experience of over sixty years.

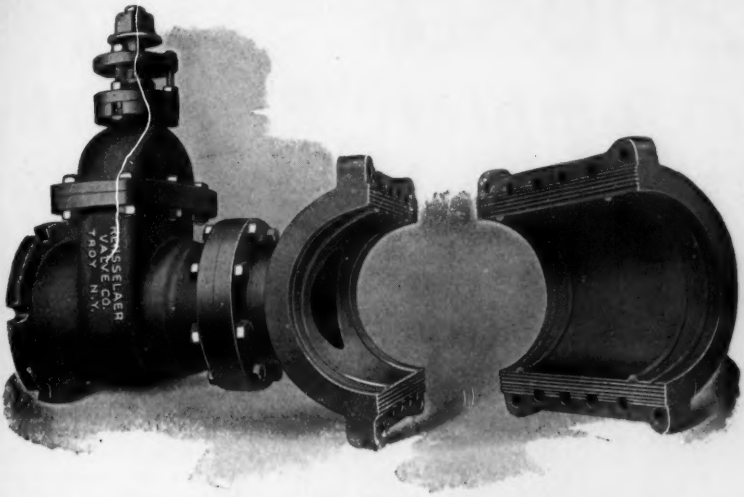
The NASH, shown above, is our latest improved model of the familiar Disc type. A fine accurate, bronze meter; very strong and reliable, and with the simplest and most economical of all frost protection features.*

NATIONAL METER CO.

299 Broadway, N. Y.

CHICAGO	BOSTON
CINCINNATI	ATLANTA
HOUSTON	SAN ANTONIO
SAN FRANCISCO	LOS ANGELES

*Made also without the frost feature, for use in warm climates.



SOME of the POINTS OF SUPERIORITY of RENSSELAER TAPPING SLEEVES

Require ***less lead*** *for Calking*
Easier to center *on pipe* ***before pouring***
Give ***Extra Pipe Protection***
Bolts require ***No Iron Washers***
Each Size *carefully* ***designed for its Working Pressure***
Can be used with all Standard Tapping Machines

Rensselaer Tapping Sleeves are the only Sleeves on the market which are built with two Raised Rings which are a part of the Sleeve Casting itself. These Rings are used as Stops for the Hemp or Jute against which the Lead is poured to make the joint. In other types of Sleeves, without Rings, the Lead, when poured, fills entire space up to point at which cut is made.

The Raised Rings also permit easier centering of Sleeves on Pipe, also permit revolving Sleeve on pipe making it easier to tighten nuts on bolts which connect the two halves of the Sleeve.

The Bolting Flanges on all Sizes of Rensselaer Sleeves are made the full length of the Sleeve, permitting a greater number of bolts to be used back of point calked, giving greater protection to pipe at point where piece is cut out. This is especially important as in some cuts a hole nearly one-half the size of pipe is cut away.

CATALOGUE "G" GIVES FURTHER PARTICULARS

RENSSELAER VALVE COMPANY

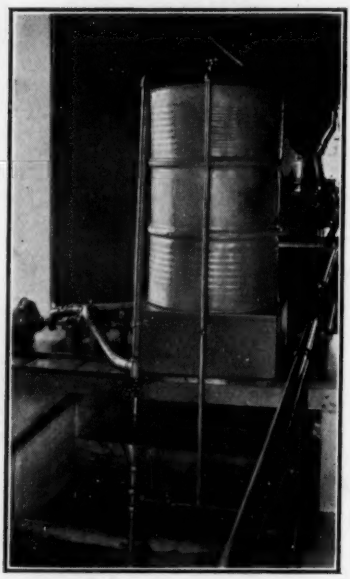
TROY, N. Y.

BRANCH OFFICES

NEW YORK, Hudson Terminal Bldg. — LOUISVILLE, Starks Bldg.
CHICAGO, Monadnock Block — SEATTLE, Arctic Bldg.
SAN FRANCISCO, Sharon Bldg. — LOS ANGELES, Subway Terminal Bldg.
PITTSBURGH, Oliver Bldg. — NEW ENGLAND, C. L. Brown, Northboro, Mass.

$200. A YEAR

for *Complete Protection* against Tastes and Odors!



50 gallon oil drum with 1" ell in bottom connected to 1¼" hose to pump. From pump to tee and back to the tank. The motor is ½ HP connected to a circulating pump from an old Willys Knight car. This was used because of the large bearings. From the bottom of the tee is a small pet cock that regulates the flow. This goes into a glass funnel so that you have a visual check. One pound of carbon is put in a three gallon bucket and well mixed. It is then poured into the barrel filled with filtered water and the pump started. It flows down the pipe leading to the filters.
"This machine has been in operation a year and has given no trouble. You will notice a thrust bearing on the end. Without this the pump will wear out in a short time."

AQUA NUCHAR

Powdered Activated Carbon

"Carbondale, Illinois, finds this a mighty small outlay for benefits received. No water plant operator should be without those benefits."

C. S. GILL, Superintendent of Water Supply.

Speaking at the Southern Illinois Water Works Operators' Conference, May 27th, 1932, Mr. Gill said:

"Using activated carbon is the lazy man's way of running a filter plant. You can have tastes and odors and not worry about them. You can apply too much chlorine and not have to worry about that. The carbon will take it out. You can have a poor color going on to the filters and the carbon will help remedy that. Carbon is, in fact, a *trouble collector*. The more of it you use, the better the effect upon the filter effluent. We use it *all the year*. We tried stopping it in the winter, but the water lost something when it was not used"

We have quoted Mr. Gill literally but wherever the term *carbon* is used above Aqua NUCHAR could be substituted. Aqua NUCHAR *is the only carbon used at the Carbondale plant.*

With Aqua NUCHAR and the simple apparatus pictured below Mr. Gill has been able to relegate taste and odor to the realm of *"things that used to be"*

The coupon will bring you full information and with it a resumé of the Round Table Discussions conducted by Water Works Engineering. These discussions include a wealth of information of value to every water plant operator. Industrial Chemical Sales Company, Inc. 230 Park Avenue, New York . . . and 205 W. Wacker Drive, Chicago.

Industrial Chemical Sales Co., Inc.
230 Park Avenue, New York

Send us information about AQUA NUCHAR and how it removes tastes and odors, also include resumé of Round Table Discussions conducted by Water Works Engineering.

Company.....

Address.....

.....

Attention of.....

J-7

5,000 Water Departments *Know that—*

Hersey Quality is Real Economy

ECONOMY, in water meters, is not a low buying cost. It is only in decreased operation expense that real savings can be made.

Therefore, it would not be fair practice for us to reduce our selling price, through introduction of poorer materials, and less capable workmanship, in order to meet "price" competition.

5,000 water departments . . . from Maine to California . . . have records which show that Hersey Meters give economical water meter service. It is our intention that such high standards be maintained, regardless of business conditions.

And to those water departments which know nothing from experience of Hersey economy and which are now being required to cut their expenses to the bone, we say this:

Only the finest of materials and the best of workmanship can assure you of the lowest possible operation expense.

Hersey Quality Has Been, and Will Be Undiminished

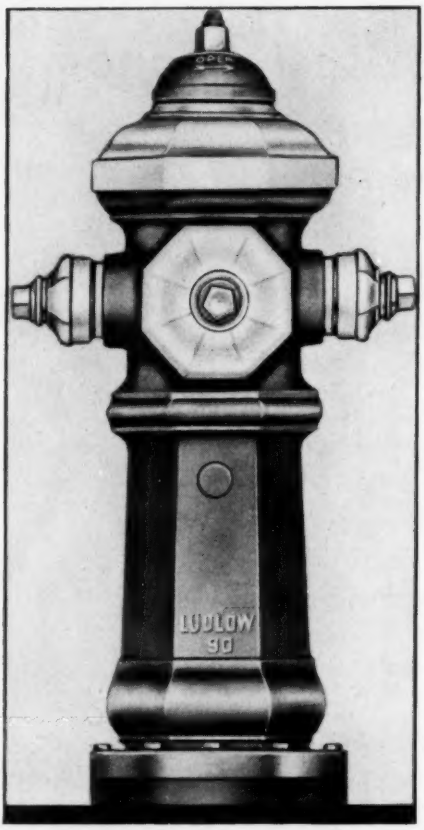
HERSEY
WATER METERS

HERSEY MANUFACTURING COMPANY

Main Office and Works: Corner E and 2nd Streets · South Boston · Massachusetts

NEW YORK CITY, 290 Broadway; PORTLAND, ORE., 475 Hoyt Street; PHILADELPHIA, PA., 314 Commercial Trust Bldg.; ATLANTA, GA., 510 Haas-Howell Bldg.; DALLAS, TEX., 402 Praetorian Bldg.; CHICAGO, ILL., 844 Rush Street; SAN FRANCISCO, CAL., 553 Howard Street; LOS ANGELES, CAL., 450 East Third Street.

REPUTATION FOR QUALITY



A national standard for over 50 years

Above Ground

Only the new Ludlow Diamond fire hydrant combines so many advantages. Design completely in harmony with modern architecture and present-day improvements in street lighting—the extra time saving safety of octagonal dome with extra light reflecting surfaces—the engineered construction features that provide ground line coupling flange, non-flooding in event of breakage and instant economical repair.

Below Ground

Only the Ludlow name and distinctive design above ground guarantee the everlasting economy and quality of the Ludlow improved valve mechanism below ground. A cost of less than 2¢ per unit per year for repair parts is the half century record of more than 8,000,000 Ludlow Valves and Hydrants in over 3,000 cities and towns, proof that Ludlow quality does insure lasting economy.

For the welfare of your city, and the protection of tax payers' pocketbooks, ***specify*** LUDLOW. Only in Ludlow Valves and Hydrants are combined all these modern features so important for the cities of "Today and Tomorrow." Backed by a reputation for quality that has been a national standard for over 50 years. Truly Ludlow has no equal.

The LUDLOW VALVE MFG. CO.

TROY · · · NEW YORK

1866 First with the Gate Valve · · 1931 The new Multi-Valve

Simplex Venturi Type Meters

Indicate the flow on a uniformly graduated dial.

Record the flow on a rectangular chart with uniform graduations.

Totalize the flow on a five-dial totalizer, so designed that the last figure can be read with accuracy on a much larger scale.

They may be furnished for floor stand, wall bracket or panel mounting.

May be used for pump discharge—gravity supply—in the Filter Plant—or Sewage Treatment Works.

Simplex Meter Registers may be checked at any time while in service by use of apparatus furnished as standard equipment—an exclusive feature of the Simplex Meter.

Simplex Meters are the choice of many who value quality and accuracy above initial cost.

Write for Data

SIMPLEX VALVE & METER CO.

6759 Upland St., Philadelphia, Pa.

AMERICAN WATER SOFTENER CO.

including by purchase

New York Continental Jewell Filtration Co.

Over 500 Municipal Purification Plants installed.

WATER FILTERS
WATER SOFTENERS
ACID PUMPS

Water Purification Equipment of every description.

DRY CHEMICAL FEEDERS	CONTROL TABLES
WET FEED APPARATUS	EFFLUENT CONTROLLERS
LOSS OF HEAD GAUGES	RATE OF FLOW GAUGES
IRON REMOVAL PLANTS	WATER SOFTENING PLANTS
CHLORINATORS	ZEOLITE WATER SOFTENERS

And Originator of the NEW ELECTRO-MAGNETIC PROPORTIONERS, with MICROMETER adjustment, for feeding all kinds of Chemicals, Coagulants, etc.

AMERICAN WATER SOFTENER CO.

Lehigh Avenue and Fourth St. PHILADELPHIA, PA.

Trade Mark

Reg. U. S. Pat. Off.

You Can Prevent Wear and Cutting of Rods, Plungers, or Shafts by Using

MABBS RAWHIDE PACKING

LASTS LONGER

Is Anti-Frictional. Saves Power and Money.

Put up in 5, 10, 15, 25 and 50 lb. pails. Price $3.00 per lb.

We make a specialty of Rawhide Meter Washers which are superior to cork.

MABBS HYDRAULIC PACKING COMPANY

431 S. DEARBORN ST. Incorporated 1892 CHICAGO, ILL.

Help Build up Your Association by Bringing in a New Member

AN APPLICATION BLANK IS ATTACHED TO THE NEWS BULLETIN IN THE FRONT OF THE JOURNAL

AMERICAN WATER WORKS ASSOCIATION

29 W. 39th St., NEW YORK CITY

Announcing—

The Kennedy SAFETOP Fire Hydrant

(Patent Pending)

If broken by collision can be returned to service

—in less than 1/2 hour
—with no excavation necessary
—at a total cost of $10.00
—without interruption of neighborhood water service

THE KENNEDY SAFETOP Fire Hydrant solves one of the most troublesome problems of the water works superintendent, and provides an important improvement to the fire protection service of a community.

If broken by a collision from truck or automobile, the Kennedy SAFETOP Fire Hydrant localizes the breakage to a Safety Breakable Section. The entire top part of the hydrant is merely dislodged from the section in the ground without injury to the major and expensive parts of the hydrant.

The replacement parts cost $6.00 and the hydrant can be returned to service by one man, with a few standard tools, in less than half an hour, and without shutting off the water supply or breaking up the pavement.

Every water works superintendent and fire department chief should learn the complete details of this important development. Be sure to write today for full information.

The Kennedy Valve Mfg. Co., Elmira, N. Y.

Representatives in principal cities

KENNEDY

VALVES-PIPE FITTINGS-FIRE HYDRANTS

The Most Modern Thing in Water Filtration Today

Klearit is the one necessary additional factor required today to modernize all water filtration equipment and processes.

Klearit eliminates all marshy, fishy, medicinal, unpleasant tastes and odors. Klearit clarifies, purifies, sweetens. Klearit enables the plant to deliver water of full 100 percent purity and palatability. *It stops complaints.*

Klearit is pure carbon. Its natural capacity to adsorb tastes and odors is increased by our special exclusive processing. It can be introduced at any point in the system. It will not clog the filter. It does not cause loss of head in filtering and it makes possible longer runs between cleanings.

Learn about Klearit. We will gladly send you complete data. Our engineering and laboratory facilities are always at your disposal.

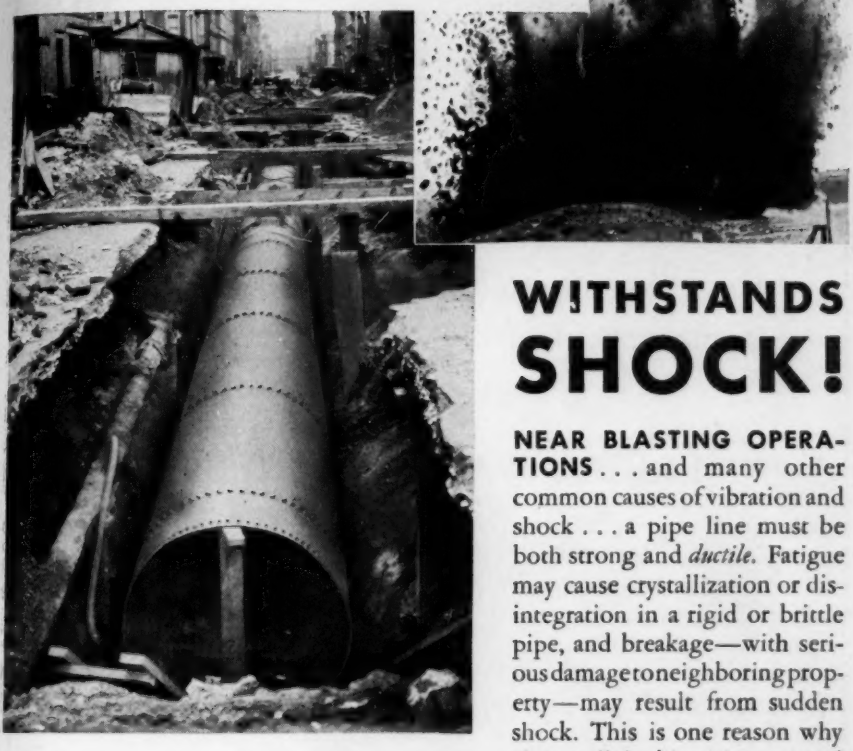
THE JENNISON-WRIGHT COMPANY
Toledo, Ohio

Branches in All Large Cities

KLEARIT

ALCO STEEL PIPE

ELECTRIC WELDED



WITHSTANDS SHOCK!

NEAR BLASTING OPERATIONS . . . and many other common causes of vibration and shock . . . a pipe line must be both strong and *ductile.* Fatigue may cause crystallization or disintegration in a rigid or brittle pipe, and breakage—with serious damage to neighboring property—may result from sudden shock. This is one reason why almost all the big cities use steel alone in their large water mains.

Alco Electric Welded Steel Pipe can be bought in quantity at extremely low cost—and its longer standard section lengths considerably reduce laying expense.

ALCO ELECTRIC WELDED STEEL PIPE
RIVETED STEEL PIPE • TUNNEL SHIELDS
RIVETED AND WELDED STEEL SHAFTING
CAISSONS • AIR LOCKS
PRESSURE TANKS • CONCRETE FORMS

•

Write for Bulletin 1010

ALCO PRODUCTS · INCORPORATED

MAIN OFFICE: *220 East 42d Street, New York, N. Y.*

DISTRICT OFFICES: *McCormick Bldg., Chicago; Magnolia Bldg., Dallas; Rialto Bldg., San Francisco; Philtower Bldg., Tusla; Barr Bldg., Washington, D. C.* Plant at Dunkirk, N. Y. *Cable Address:* Alproducts

DIVISION · OF · AMERICAN · LOCOMOTIVE · COMPANY

IMPORTANT

THE Association has run short of certain numbers of the Journal. Any members who do not desire to preserve their copies of the following issues and are willing to return same, will be acting to the benefit of the Association.

AMERICAN WATER WORKS ASSN.,
29 W. 39th St., New York, N. Y.

January and March,	1920
January and March,	1922
January, March, May, July, and September,	1924
All issues for	1926
January, February, March and April,	1929
January, February, March, April and May,	1930

THE NEW NECESSITY for WATER METER QUALITY

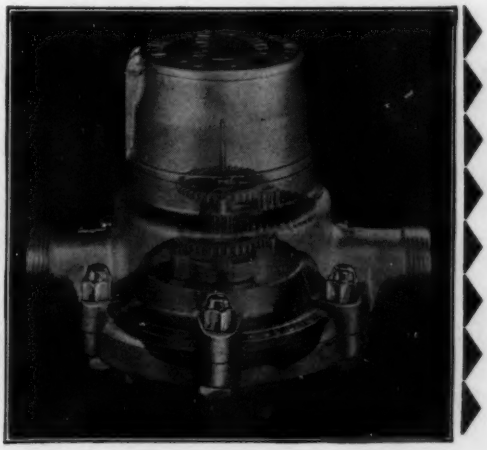
With municipal tax rates rising and revenues all pledged to meet other needs, the least that the city waterworks should do is to be self-supporting. This not only requires water meters, but the most accurate meters.

Full revenue must be earned from every meter if waterworks budgets are to balance or show a profit. The small leaks and wastes that once were overlooked, must be stopped. Uncompromising accuracy must be demanded. Yet initial cost must be kept within reason.

American and Niagara Water Meters meet both requirements by having the simplest design of any meters made, combined with the finest grade of materials and precision machining. They have extreme accuracy and maintain it with less friction, less wear. And still the cost is moderate because complicated construction is avoided.

Write today for further information on the economy of American and Niagara Meters.

Buffalo Meter Co.,
2914 Main Street,
Buffalo, New York



NIAGARA (IRON CASE) and AMERICAN (BRONZE CASE) Water Meters

ZEOLITES*

for municipal and industrial water softening

MADE by the originators of zeolite water softening. Nearly twenty years' experience. Extensive research and laboratory facilities. The Permutit Company, 440 Fourth Avenue, New York City.

***ENDURITE**

The original glauconite (greensand) zeolite. Specially processed for maximum ruggedness and uniformity.

***DECALSO**

The original, wet-process synthetic zeolite. High-exchange capacity—strong grain structure.

***SPECIAL ZEOLITES**

For removal of manganese, etc. Other zeolites made for special conditions.

MADE BY THE MAKERS OF

Permutit

Water Treating Equipment

WANTED

Used Pressure Water Filters in good condition, approx. 600 sq. ft. total sand area. Sizes desired three 9 ft. dia. x 20 ft. long or three 8 ft. dia. x 25 ft. long or four 8 ft. dia. x 20 ft. long. Complete with internal and immediate external fittings.

DU PONT RAYON COMPANY

Station B, Buffalo, N. Y.

SERVICE BOX CLEANER

for

Cleaning and removing from service boxes dirt, stones, bricks, bottles, roots, etc. in fact any obstacle that might become lodged in these boxes

Order one and give it a TRIAL

WE Guarantee it

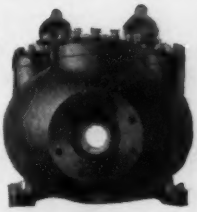
WATER WORKS EQUIPMENT COMPANY

50 Church St. New York, N. Y.

S-l-i-p-p-i-n-g through your fingers?

Are you getting *all* possible water revenue? Are you metered properly on all services? Have you reached the lowest possible figure on water meter maintenance?

Unless you are *certain* you are doing these things now—investigate Trident and Lambert Water Meters. Investigate their possibilities of added revenue, through their sustained accuracy and great sensitivity. Investigate the great economies of their *interchangeable unit parts.* Find out why nearly 6 million have been made and sold—why experienced water works men select them—why they are known as the "Cash Registers of the Water Works Field." It is a story of quality, of prestige, of experience, . . . of making and saving money for water works men. Remember, there is a Trident or Lambert Meter for every problem of water revenue production. Write for Catalogs to Neptune Meter Co. (Thomson Meter Corp.), 50 East 42nd Street, New York City . . . also Neptune Meter Co., Ltd., Toronto, Canada.



TRIDENT PROTECTUS

The first fire service meter officially approved by the Underwriters' Laboratories, Inc. Note clear waterway through the meter on high volume fire service.

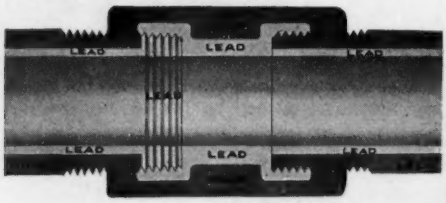
This is the sign of maximum water revenue all over the world.

Pioneers in Meter Progress—Yesterday, TODAY, Tomorrow

trident

AND LAMBERT WATER METERS

This shows Pipe just entering Lead Threads of Fitting



This shows Pipe Screwed into Lead Threads and Shoulders of Fittings

For Dependable Service Installations

"Wakefield Galvanized"

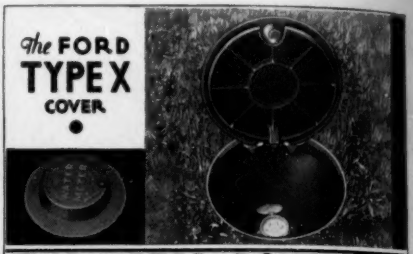
Amalgamated Lead Lined Iron Pipe and Fittings

Low Cost—Easily Installed—Permanent

Inquiries respectfully solicited

LEAD LINED IRON PIPE COMPANY
WAKEFIELD, MASS.

The **FORD TYPE X COVER**



THE METER BOX COVER WITH THE *HINGE EFFECT!*

A Real Boon to the Meter Reader

WHEN you buy meter box covers, consider the man who reads the meters and opens hundreds of meter boxes every day. The Ford Type X cover with the hinge effect, *saves time and effort with every meter reading.*

Notice the illustrations above and at the left. The lid may be leaned back as though it were hinged. *No mud, snow or leaves are dragged into the meter box when the lid is replaced.*

Write for prices

The **FORD METER BOX CO.**
WABASH, INDIANA
WATER METER TESTING AND SETTING EQUIPMENT

Warren Foundry & Pipe Corp.

ALSO

Warren Pipe Co. of Mass., Inc.

SALES OFFICES

11 BROADWAY, NEW YORK
75 FEDERAL ST., BOSTON, MASS.

Manufacturers of

CAST IRON PIPE

Flanged Pipe ***Flexible Joint Pipe***

Bell and Spigot Pipe

Special Castings ***Short Body B. & S. Specials***

Warren (WF) Spun Centrifugally Cast Iron Pipe

WORKS: PHILLIPSBURG, N. J. and EVERETT, MASS.

Large Stock Enables Us to Make Prompt Shipments

FOR EMERGENCY: ACCEPT NO COMPROMISE!

The strongest characters insist upon and invariably enjoy the best. In emergency a mediocre unit, speeded beyond its designed running range, invites a hazard, a failure, a loss. There is no need to accept less than a Sterling engine offers. Booklets, 7 minutes reading each, will acquaint you with what you want to know.

Sterling High Duty

Internal Combustion Engines

12 to 565 B.H.P. Gas or Gasoline

At Appleton, Wisc., a Sterling GRC-8 cylinder 240 H.P. 1200 R.P.M. engine direct connected to a DeLaval pump requiring 177 H.P. at 1150 R.P.M.

STERLING ENGINE COMPANY Dept. C-3 **Buffalo, N. Y., U. S. A.**

Something New and Needed

Water Purification Control

By EDWARD S. HOPKINS

Principal Sanitary Chemist, Bureau of Water Supply, Baltimore, Maryland

A short, non-technical guide book for the instruction and personal use of the water works operator.

Abel Wolman Says

"The number of texts of a purely operating character is limited. Those that are good are somewhat out of date. This volume fills a current need.

"To improve and guide the operator is the primary function of this book. It is designed, in simplicity of language and arrangement, to meet the needs of the rank and file.

"This book should be on each operators desk."

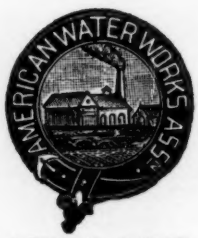
—Excerpts from the Foreword

Thirty-five illustrations. Many useful tables. References to the literature appended to each chapter. $1.75

THE WILLIAMS & WILKINS COMPANY

Publishers of Scientific Books and Periodicals **Baltimore, U. S. A.**

BADGES THE AMERICAN WATER WORKS ASSOCIATION



OFFICIAL BADGE

This cut is a facsimile, enlarged, of the official badge or emblem of the association. It is of gold and blue enamel made with a pin, but can be made into a button or watch charm.

The price in solid gold is $5.00 and they can be procured by addressing

AMERICAN WATER WORKS ASSOCIATION
29 West 39th Street, New York, N. Y.

These badges are not to be confused with the usual convention badge, but are for everyday use

Position Wanted

M.A. in Chemistry from well known university desires position as chemist or operator of water plant. Four years experience. Any location. Available immediately. Excellent references. Moderate salary.

Inquire of
American Water Works Association
29 W. 39th Street
New York, N. Y.

CONNECTION desired by member of A. W. W. A. with twenty years' experience in sales work in water purification—inside, outside and executive. Prefers position which will utilize nationwide acquaintance; but will consider midwest or southern agency for one or more good lines. Can sell anything, carry on existing program or make new one. Well fitted to introduce something new.

Inquire of American Water Works Association, 29 West 39th Street, New York, N. Y.

Position Wanted

Engineer-Chemist, age 35, ten years with city of 36,000 population in charge of water, light and sewer systems, water filtration and two modern sewage treatment plants, desires position as Superintendent, assistant to Superintendent, or Plant Superintendent.

Inquire of:
American Water Works Association
29 West 39th Street
New York, N. Y.

Position wanted by Chemical Engineer. Forty years old, twenty years experience. Capable of acting as City Manager, operating water department, water purification and softening plant, sewage plant, experienced in mosquito control, milk problems. Can make own laboratory analysis. Qualified to do all of the above in a small municipality, or any in a larger. Salary nominal. Steady job desired.

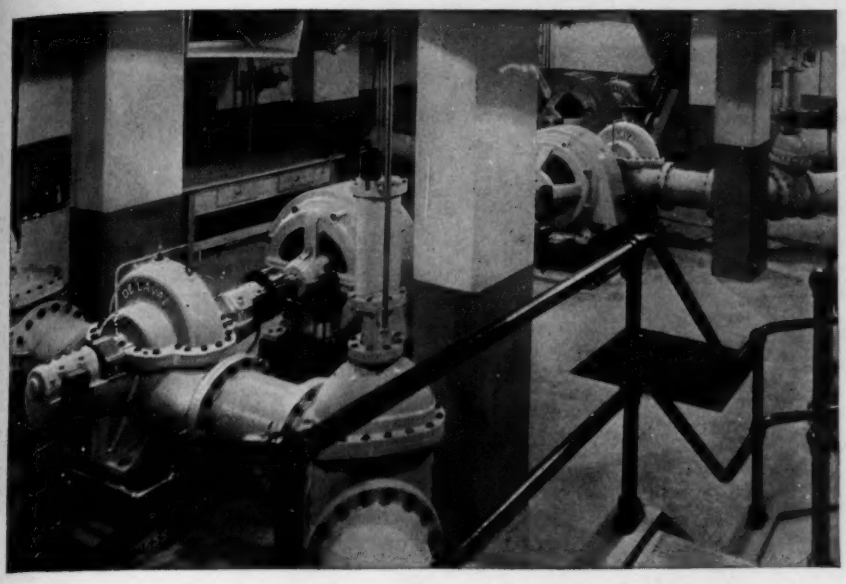
Inquire of American Water Works Association, 29 W. 39th St., New York, N. Y.

Help Build up Your Association by Bringing in a New Member

AN APPLICATION BLANK IS ATTACHED TO THE NEWS BULLETIN IN THE FRONT OF THE JOURNAL

AMERICAN WATER WORKS ASSOCIATION

29 WEST 39TH STREET
NEW YORK CITY



Automatically Controlled DE LAVAL PUMPS

THE Guilford Pumping Station, in the residential district of Baltimore, requires a minimum of attention, as it is completely automatic in operation and is equipped with De Laval Centrifugal Pumps.

Two of these pumps deliver 10,000 gal. per min. each against 193.5 ft. head and two 7150 gal. per min. each against 188 ft. head, all at 1200 r.p.m.

An important feature of these pumping units is the use of De Laval labyrinth wearing rings, which permit large internal clearances and eliminate the relatively rapid dropping off of efficiencies so frequently found in pumps equipped with close clearance, flat wearing rings.

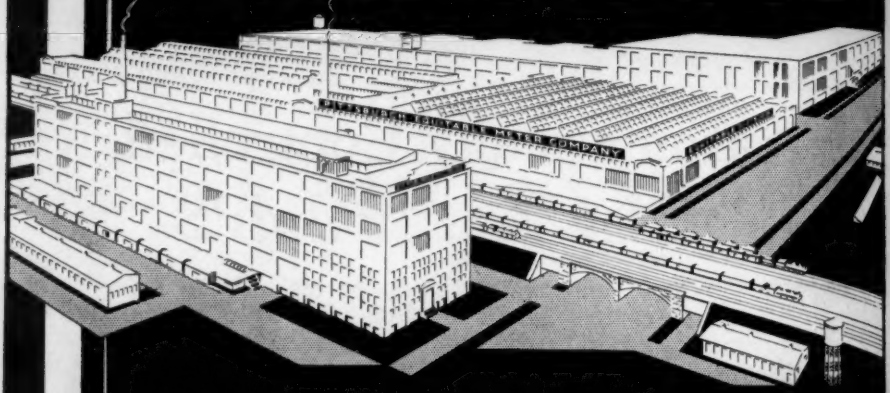
During the past 11 years the City of Baltimore has installed 10 De Laval Centrifugal pumping units in four different pumping stations, aggregating in capacity nearly 200 million gallons per day.

DE LAVAL PUMPS GIVE SATISFACTORY SERVICE

De Laval Steam Turbine Co.,
Trenton, New Jersey

4054

PITTSBURGH WATER METERS



ARE BUILT in a modern factory equipped with the latest types of machinery which enable skilled workmen to produce quality WATER METERS.

Our own laboratories are maintained for testing all raw materials and are available to Water Works Operators for the scientific solution of their problems.

Branch Factories, Offices and Warehouses, carrying complete stocks, located strategically throughout the country, plus a large, capable sales force assure the utmost in service.

PITTSBURGH EQUITABLE METER COMPANY

Main Office and Factories—Pittsburgh, Pa.

New York · Tulsa · Salt Lake City · Los Angeles · Columbia · Chicago
Davenport · Dallas · Seattle · Houston · Kansas City